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ARPANET MANAGEMENT STUDY: NEW APPLICATION AREAS

Carson E. Agnew, et al

Cabledata Associates, Incorporated

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Overall project explores new applications for transfer of technology developed by ARPA-IPTO. Present report discusses technical and economic feasibility of widespread computer netting technology usage to aid DoD procurement effectiveness. Considers goals and objectives; technical and economic feasibility analyses, state of the art and technical and policy issues in preservation of secrecy in distributed computer based system design. Also examines costs of transmitting one-way messages using alternative technologies.

C A B L E D A T A   A S S O C I A T E S, I N C.

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ARPANET MANAGEMENT STUDY: NEW APPLICATION AREAS

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ABSTRACT

This Quarterly Technical Report describes work in progress by Cabledata Associates for the period May through July 1974. The thrust of the work reported is in the formulation of a basis for technological transfer of research in computer netting, with emphasis on specific technical, economic and institutional factors present in applying computer netting to the defense procurement process.

The previous Quarterly Technical Report described the magnitude of the potential savings. Work in the present period considered subsystems required, and compared them to those in place and now providing effective automation of many procurement functions. The big gap is (1) a detailed image or statement of the full degree of information automation possible and desirable that is within the anticipated near-term state of the art, (2) a specific blueprint of "how to get to there from here," and (3) a plan to utilize low cost computer netting for procurement functions. This last step is particularly close to ARPA-IPTO's interest, as it requires direct technology transfer of work previously undertaken by ARPA-IPTO.

Some specific topics addressed in the present Quarterly Technical Report include:

1. Consideration of system modules necessary for a large set of procurement related functions.

2. Description of an early list of evolutionary functions felt to be most applicable.

3. Determination of the file sizes for the records considered.

4. Determination of the state of the art of inputting and storing the large text database implied in automating procurement.

5. Consideration of secrecy protection means that are more effectively built into the initial system configuration design rather than as an afterthought.

6. Survey of present procurement information automation efforts, and consideration of evolutionary growth from this presently highly advanced basis.

7. Analysis of the cost of sending one-way text messages via a number of alternatives ranging from postal mail to various forms of electronic transmittal.

8. Work in progress in evaluating present day legal interpretation of governmental secrecy provisions and private proprietary information protection legislation of import to procurement automation.

I. CONTENTS

INTRODUCTION

This Quarterly Technical Report is primarily a review of work in progress. The appendices, which were originally prepared as internal working papers, deal primarily with procurement. Our reasons for selecting procurement as a domain ripe for transfer of *ARPANET* technology are reviewed in Chapter II of this report. The goals of this overall project are contained in the First Quarterly Technical Report, *ARPANET MANAGEMENT STUDY: New Application Areas*. (R-148), and will not be repeated here.

This report consists primarily of appendices which contain the meat of the report. One Table of Contents serves for both the report body and its appendices, as do the List of Figures and the List of Tables. This chapter of the report describes some of the highlights found in each appendix.

APPENDIX A: A PHASED IMPLEMENTATION PLAN FOR A PROCUREMENT AUTOMATION SYSTEM

This first Appendix (A) discusses a phased implementation plan for a hypothetical procurement system for DoD. This long term end-point system is called a Procurement Automation System (or PAS). The Procurement Automation System described in this paper represents the form which DoD's procurement management information system might assume a decade hence. Some of the modules needed to perform many of its functions are to some degree already in existence. Several, however, will have to be created in order for the full system to be achieved.

Appendix A describes all the modules considered and suggests a chronological order in which those which do not yet exist would be built. This order is determined partly by technical constraints and partly by the degree to which each module interacts with and supports different procurement functions. For instance, an on-line file which permits access to fully updated procurement regulation documents such as ASPR is suggested to be implemented early (Phase 1) because the technology for doing so is available in the near term and because ASPR forms the core of the overall procurement regulations. (See Table A-2 of Appendix A, which shows the interaction of Procurement Automation System applications with procurement functions.)

Phased implementation discussed in this appendix seeks to allow the DoD to:

- obtain some quick benefits during the early phases of implementation;
- reduce the risks of relying on new hardware or software;
- gain experience with aspects of PAS operation;
- reduce the peak investment required for the automated system.

Appendix A also discusses some different software elements required by the Procurement Automation System to support the applications which will be implemented. Besides an operating system, at least nine major software modules will be needed to achieve the proposed fully developed Procurement Automation System targets. At the moment it appears that all but two of these are found to some degree in existing systems. But, tying together these disparate systems is not an easy task. A major reprogramming effort will be required to transfer portions of existing software to advanced hardware. The phased implementation plan suggested provides for an interim implementation on existing equipment followed by a re-implementation on advanced equipment.

APPENDIX B: PROPOSED APPLICATIONS FOR A PROCUREMENT AUTOMATION SYSTEM

Appendix B discusses four important functional capabilities to be included in the Procurement Automation System. Several of these are already available in one form or another on current DoD systems.

For instance, the LITE and Avionics Central systems include features which are compatible with the On-line/ASPR application discussed in this appendix. The four application areas or subsystems labeled On-line/ASPR, On-line/RFP, BROKER and SCOREBOARD are briefly described below.

On-line/ASPR

An on-line file of ASPR and related procurement regulations would form a subsystem for procurement management. The system would replace or supplement the current hard copy ASPRs with an on-line file accessible in real-time. Access to the file would be by indexes to all the key words in the text, and by section organization and internal or external cross-reference. These indexes would make it possible to quickly find a requested passage or all relevant passages on a particular subject. It would be possible to trace cross-references and their antecedents in a way now impossible. The file would occupy perhaps 10^8 characters in all (roughly half of a double-density IBM-3330 disk pack).

On-line/RFP

The second subsystem described is used to prepare internal procurement documents on-line. This application supports the creation, editing, review and final preparation of documents such as work statements, procurement requests, justifications, budgets, requests for proposal and invitations for bid. These documents form the basis for much of the procurement paperwork needed for management and control. Since much of the text is reused throughout the course of a procurement, an on-line file which could be updated in real-time would reduce the paper workload. The text editing capabilities of this system would be supported by a text editor system and a convenient terminal system. The text editor could have some of the structured text capabilities of systems such as NLS (but more readily adapted to non computer-experts). This would allow boilerplate and fine print to be referenced without necessarily appearing when the text is composed or edited. The terminal system would most likely use "smart" terminals incorporating considerable local editing capabilities and some local storage. The terminal and software hopefully would be designed to overcome some of the current human factors limitation of existing text editor systems. This application would also provide for review or conferences over a particular document by a system similar to current on-line conference systems.

Broker

The third subsystem discussed in Appendix B is called BROKER. BROKER is an information system for procurement of high technology items which are characterized by rapid technical progress, high unit cost and the absence of standard features. Examples of typical high technology items are digital computers, integrated circuits and laboratory test equipment. The BROKER system would be intended to enlarge the area in which competitive procurements are possible and to reduce time lags between the appearance of a new technology and its use by DoD. BROKER would maintain current information on the cost and capabilities of high technology items produced by a variety of suppliers. Emphasis would be on timely content and ease of search of the database, cutting down the time required to reach a procurement decision.

Maintained by DoD personnel, BROKER would provide a centralized repository of all the firms who are capable of supplying an item. This would make it possible to expedite the procurement process by insuring that all competitive firms are considered by a potential buyer. The BROKER system could be extended for use by contractor design engineers and purchasing agents. This service would supplement presently available general purpose catalogs produced by both private industry and government organizations. To ensure honesty in the database a feedback mechanism would be incorporated, allowing purchasers to register their comments and suppliers to rebut them.

Scoreboard

A fourth application area is a SCOREBOARD subsystem. SCOREBOARD is a schedule monitoring system for large procurements. The system would maintain several coordinated files and indexes to them for use by the Defense Department and its contractors. The files would show the status of contractors' current and proposed work and the schedule for its next phases. Corresponding information on the status of proposals and contracts within DoD would be maintained. Names of contractors and their personnel with DoD agencies and their personnel would be maintained in a second file, so that it would be possible to ask, "What's so-and-so doing?" as well as, "Who's doing such-and-such?" SCOREBOARD would use a general purpose information system to maintain its database, updated in real-time as changes occur and providing easy access to the information at many different locations. From the contractors' point of view, a SCOREBOARD would relieve some of the uncertainty now associated with government work by making it possible to examine the chronology and actors in decisions (who made what decisions, when and why). This could do much to increase openness and competitiveness with which procurements are conducted by DoD. This should result in dollar savings to the nation, as well as a reduction in the level of suspicions with regard to the nature of non-competitive defense spending.

APPENDIX C: SIZE AND COST OF STATIC FILES FOR A PROCUREMENT AUTOMATION SYSTEM

An important part of the Procurement Automation System is its text database. Appendix C discusses the size of static files whose nature is relatively unchanging. Typical static files are the ASPR and the U.S. Code. Other regulations produced by the various services and commands are also static files. The estimated size of these files is currently quite large, approximately 1.7×10^9 characters. The advancing state of the art in OCR technology may make it possible economically to convert the text of these documents into machine-readable form, but a comparable ability to handle the graphics contained in these documents is currently lacking. For this reason, this appendix concludes that it is not at present possible to keep *all* the procurement documents on-line. However, it does appear to be both practical and useful to maintain a file of high level documents of text on-line. This file might be considerably smaller than the total database, and at minimum perhaps 5×10^7 characters.

This appendix investigates in some detail the technologies of optical character recognition (OCR) and computer graphics. It concludes that a revolution is occurring in OCR technology which may significantly reduce the cost of converting ordinary printed text into a machine readable form. If the text had to be keypunched, it might cost .4¢ to 1¢ per character. OCR technology can reduce this cost to about .014¢ per character and also can substantially reduce time required to convert. The survey of graphics technology indicates that microform graphics, while their technology is adequate, would not provide an adequate level of service for the large files that are envisioned here. It concludes that digital encoding methods are not yet advanced enough to be practical, and that facsimile methods would not provide quick enough response time to be useful for storing pictorial information in most applications.

APPENDIX D: HARDWARE/SOFTWARE PRIVACY AND SECURITY CONSIDERATIONS

Appendix D limits itself to the computer/communications portions of the system design. This work is presented not as a systems specification. Rather it describes how the protection from unauthorized access to proprietary or classified data can be facilitated by addressing privacy and security at the beginning of the system design. This appendix discusses several ways of achieving adequate privacy and security. These include the use of cryptographic techniques based on initial use of enciphering and deciphering hardware together in a system software design which limits user access to the system resources. The appendix describes a user authentication scheme; the compartmentalizing of particularly sensitive data, and means for provision of adequate proof tests and audit trails for the system.

Of particular interest in this paper is a technique proposed using LSI technology to make it economically feasible to encrypt all transmission to or from all host computers and files. In addition, in those cases where needed by special agency files, super-encryption is proposed to be applied individually to files and data providing an additional layer of protection. The appendix considers the design of a key generator whose operation (at least in the opinion of the author) is exceedingly difficult to reconstruct in the absence of knowledge of the key base used and even when the cryptanalyst is in possession of the hardware device. It is suggested that the hardware encryption also be coupled with an additional aspect of system software design, namely the use of Huffman encoding for network transmission. (Huffman coding is a technique whereby the natural redundancy of a language is removed prior to the transmission of data.) The elimination of such redundancy greatly adds to the burden of attempted decryption of any intercepted transmission. The goal of this appendix is to suggest that a combination of these two techniques could help make the Procurement Automation System security system capable of consideration for NSA certification.

APPENDIX E: PRESENT STATUS OF PROCUREMENT AUTOMATION IN DOD

The Procurement Automation System is an advanced management concept requiring a number of critical modules. A field survey of existing systems relating to DoD procurement and systems in design was conducted in the summer of 1974 and is reported as Appendix E of this report. Briefly, the survey found that most of the modules necessary to implement the Procurement Automation System design are to some extent in use or in development in one of a number of independent systems. Lacking are cost-effective communications links, a real-time computer netting capability, and an overall system architecture.

Surveyed were systems to aid logistic and systems procurement, contract administration and several systems which could be classified as "information utilities." Most of the ten systems surveyed dealt primarily with logistics and support activities. Several are "mature" and fully operational. Several more will be implemented by 1975. The activities surveyed include many hundreds of user sites, dozens of computers, and enormous databases distributed world-wide. They monitor procurement transactions worth billions of dollars. The procurement automation "community" has accumulated 10-15 years of generally successful experience with relevant management and computer techniques and the survey found an OSD conceptual commitment (through MILSCAP) to a unified DoD procurement information system. Somewhere within each of the ten systems we found that all but four of the necessary Procurement Automation System elements sought existed to some extent. The four weakest elements were:

1) absence of adequate external interface standard ;
2) absence of adequate, cost-effective communication links;
3) absence of a computer networking capability;
4) absence of an overall Procurement Automation System architecture.

This is not to say that communication doesn't exist, nor that networking is completely lacking, nor that system architecture does not exist. Each exists to some extent. What is lacking is *degree*. More effective and wider spread communication and networking capability are essential if the diverse systems currently in existence are to be unified by 1985. A detailed plan for the emerging system is equally essential. Despite the commitment toward a unified facility, in the absence of such a plan DoD could easily arrive at 1980 with two or three times the present number of diverse systems and the accompanying high costs of in-compatibility.

APPENDIX F: GOVERNMENT PROCUREMENT: A CASE STUDY IN THE ECONOMICS OF INFORMATION

Appendix F considers a view of the economic theory of the general problem of governmental procurement, applying concepts from the newly emerging theory of economics of information.

The paper argues that procurement is a unique non-market activity in the sense that normal competitive price-demand market mechanisms are, for one reason or another, not fully operative. Some of the reasons that this is so are:

1) buyer uncertainty,
2) bid uncertainty,
3) supplier uncertainty,
4) coordination uncertainty.

The nature of these "market failures" (in the jargon of economics) is discussed in the paper, which revolves around information problems inherent in the procurement process itself. The paper suggests that many of the delays, cost overruns and misunderstandings inherent in large systems procurements can be improved in a significant manner by better information flows internally within the procuring agency and externally to the contractors themselves. The market failure is said to produce a large cost "iceberg" where the tip of the iceberg represents the large procurement establishment (manpower) while deeper in the iceberg are such less tangible costs as:

1. The cost of procuring an untimely system.
2. Costs of failure to encourage feedback and learning during the procurement process.
3. Opportunity costs lost by unnecessary delays.

The paper concludes that the market failure can be partially corrected by restructuring the procurement market. This restructuring can be accomplished on an organizational level only after the technology permits the necessary information flows.

APPENDIX G: THE COSTS OF ELECTRONIC MESSAGES

In addition to examining procurement functions, a study was conducted to answer the question, "what are the real costs of a message communication system?" This appendix considers and compares the characteristics and the costs of the following media:

1) postal communication (First Class and Registered mail),
2) telegram (day telegram, night letter, mailgram),
3) SNDMSG,
4) Telex and TWX,
5) intelligent terminal plus DDD,
6) facsimile,
7) telephone answering device.

The analysis considers not only the cost of transmission, but also the value of the sender's and receiver's time. When such time value in the communications process is realistically valued, all of the media show remarkably similar costs -- roughly $6.00 for a 125 word message. This uniformity in cost strongly suggests that only qualitative differences (time and convenience) among the technologies should be the important determination in choosing between these alternatives and preoccupation with visible costs could produce false economics. Perhaps the lowest cost alternative suggested in this appendix is the use of an intelligent terminal storing messages and calling at 11:00 p.m. to obtain the $.35/minute telephone tariff. The approximate costs of the alternatives are shown in Table 1 which reproduces Table G-10 in Appendix G.

APPENDIX H: COMING ATTRACTIONS

Some of the system assumptions implicit in the work on the automation of procurement derive from a section of the report not scheduled for publication until mid-October. This section is being prepared by Paul Goldstein following his investigation of the role of secrecy in procurement automation. Much of the information involved in procurement is by its very nature, sensitive. Goldstein's work argues that national security might better be protected by a presumption against secrecy rather than counting upon it alone for protection.

Table 1

COST COMPARISON OF SOME ALTERNATIVE SIMPLEX COMMUNICATIONS SERVICES

(BASIS: 125-WORD MESSAGE)

Speed Range	Delay Time	Service	Cost Estimate, $
Immediate	None	Intelligent terminal + DDD auto dialer	6.15
		TWX tape	6.50
		Voice telephone answering device	7.03
		Telex tape	7.25
		Facsimile	5.95-9.33
		Interactive TWX	11.31
On user's demand	0 to days	SNDMSG	6.36
Slow	3 hours	Telegram, full rate	20.65
Overnight	est-12 hours	Intelligent terminal late night message transfer	5.05
	est-15 hours	Night letter	7.45
	1 to 2 days	Mailgram	6.20
	1 to 3 days	First class/Airmail	6.10-7.10
	2 to 4 days	Registered mail	6.70-7.80

We plan to re-issue the appendices from both the First and Second Quarterly Technical Reports and combine the work on secrecy with some other material in progress so that Cabledata's investigation of the subject will be drawn together as a single report on procurement automation for later issue.

II RATIONALE

WHY PROCUREMENT AUTOMATION?

We did not set out to examine procurement automation per se. Rather, we selected this subject for detailed study after first examining the entire defense budget and labor categories budgets. Procurement stood out as a particular target worthy of very careful examination. In the course of this examination we became convinced that large savings -- perhaps on the order of $100 to $200 million per year -- were achievable.

Our study of the defense budget separated the dollar flows into two categories. One, where there was a high component of information flow, especially among geographically dispersed locations. And, two, those expenditures where information processing was a relatively small value-added component; these were not considered further.

Our study of DoD manpower revealed that labor represents the major and most rapidly increasing cost component. We found that in the information-intensive labor domain most of the dollars could be accounted for, particularly in procurement, in the salaries of the mid-level personnel -- especially GS levels 11 through 13. These appeared to comprise work descriptions that combined a large component of highly repetitive work with managerial judgment. With regard to the potential payoff for higher GS level tasks, automation proved much more difficult and further from the present state of the art. Automation of simple clerical functions, such as those performed at the lower GS grades, showed smaller potential savings owing partly to the already effective computer automation of many such jobs. At levels of management above GS-14, the total wages are very much smaller than in the GS-11 through 13 target grouping.

TASKS AMENABLE TO INFORMATION AUTOMATION

When we considered the procurement process in detail, we found it to be a natural application of computer netting. A multiplicity of different locations are involved in a process that requires a great deal of communication. Reference to large files is needed. Many standardized forms are involved. Aided text editing is required. Many people need access to the same database. The same information, but in different form and processed slightly differently, is required by different users. Time delays are often critical. Privacy protection is required in different forms in different files.

INSTITUTIONAL CHANGES REQUIRED

The procurement process, especially for large-system procurements that consume most of the dollars, is a geographically distributed activity. Historically, the entire system dates from one where a single sheet of paper was passed from hand to hand, from start to finish. In the aftermath of procurement scandals, the number of consecutive signatures increased with the introduction of additional safeguards. To fully utilize the benefits of information automation, it will be necessary to change the procurement process itself. We envision the entire process evolving from a serial one to a parallel one, to the maximum degree possible.

Computer netting can have a major impact in raising the effectiveness of the procurement process provided that the process is slightly modified in form and procedure to match the opportunities and limitations of computer systems technology. For example, the procurement process could be modified to allow budgets and secondary activities to respond more rapidly to a changing environment. Much information can be kept in a computerized database, eliminating the need for much "boilerplate." Greater confidence can be placed in the trustworthiness of each individual because of the availability of a complete audit trail of who did what, when, and why. The exact status of any procurement can be instantly determined and bottlenecks made known to each person or agency involved. Feedback on a source-protected basis could permit review of the fairness of the procurement activity by including evaluations of the winning bidder, the procurement and the technical personnel by the losing bidders.

CHANGED SOCIAL ENVIRONMENT IN THE 70's AND 80's

The concept of opening up the procurement process to inspection by losers and the public, as is being considered, may appear novel or even radical. But, if our evaluation of the changed and changing political and social environment of the nation is even partially accurate, such capabilities may become mandatory in any future procurement system, whether automated or not. In our present study on procurement automation we see two social changes that hold great significance to the designers of the procurement process of tomorrow. The first is the growing public distrust of all institutions and the second is the diminution of the effectiveness of governmental secrecy. (This will be discussed in the working paper in preparation by Prof. Paul Goldstein, scheduled for October 1974.) The efficacy of governmental expenditures, especially defense expenditures, is open to question. The terms and conditions of public/private contracts is viewed by some sectors of society in an almost paranoid manner. The scope of the Freedom of Information Act has been expanding as have the actions for discovery and objection taken under this act. This, coupled with a rapid erosion of the effectiveness of national security/secrecy policies, suggests to us that diminishing reliance can be placed on military secrecy in the future unless there is a major revision of the relevant law and its interpretation. These are complex subjects in themselves, but they do provide us with some important guidelines in our systems synthesis planning. First, they suggest that the present procurement system will be much more open to inspection and objection than in the past. The costs for this alone could be major and time consuming, and possibly debilitatingly expensive, unless the system is designed to accommodate this need. Second, the future cannot be safely trusted to provide any major protection to sensitive information. Rather, it is more realistic to design a system under the assumption that the use of secrecy protection will rapidly diminish with time.

MAGNITUDE OF TARGET SAVINGS

In all our estimates we consider not a blanket wholesale substitution of personnel in procurement, rather only a minor reduction of the staffs required to handle a given volume of work in a given time. Even so, directly measurable annual savings on the order of $100 to $200 million per year appear achievable. Aside from the directly measurable savings in reduced personnel requirements, we would receive major intangible benefits of more rapid procurements, better fiscal and technical control, and the ability to provide more trust and freedom of action for each decision maker in the process.

LABOR IMPACT: WHERE WILL THE SAVINGS OCCUR?

We found that of those persons whose jobs would be eliminated, most tended to be near (within 10 years) the date of their retirement. As a practical matter, the persons replaced by this system need never in any case be fired. Rather, normal retirement attrition would be more than adequate, when we consider that a system of the type we envision would not come in at one time tomorrow. Rather, the implementation would take place gradually over an extended period. Further, since the system is basically designed to serve a geographically distributed clientele, staff surpluses at one location could more readily make their skills available to other locations without physically moving. Thus, we believe that a detailed plan for the procurement automation proposed will be able to identify specific jobs capable of replacement and present a plan for minimal disruption to long term career employees. This is desirable both as a matter of good social policy, and to minimize the objections by the affected group.

PRESENT STATUS OF INFORMATION AUTOMATION IN PROCUREMENT

Today computer automation has already been effectively applied to the more routine defense supplies purchasing function. But, it has not to a major extent been felt in the more complex procurement actions. Our effort is therefore directed at helping today's procurement MIS evolve into an integrated system to meet future needs.

APPENDIX A

A PHASED IMPLEMENATION PLAN FOR A PROCUREMENT AUTOMATION SYSTEM

by

Carson E. Agnew

INTRODUCTION

This appendix is a companion to Appendix B, which discusses the four most important new functions of the Procurement Automation System (PAS). This paper outlines a phased development plan for the implementation of those functions, as well as the other functions which make up the complete PAS. A phased approach to the PAS was chosen because of its large ultimate size and because some of its proposed applications are not yet technically possible. A phased implementation also allows us to:

- Obtain some of the benefits in the early phases of operation;
- Reduce the risks of relying on new hardware or software for certain procurement capabilities;
- Gain experience with certain aspects of PAS operation;
- Reduce the peak investment required for the automated system.

NOMENCLATURE

Throughout this working paper certain words have been used consistently to distinguish between automated operations, programs and manual activities carried out in procurement. An *activity*, as used in this paper, is some operation performed in the course of a procurement. A *function* is several activities with some common purpose or with some common attributes. Some typical procurement functions include the drafting of work statements, RFPs and IFBs; and source evaluation and selection. An *application* consists of those portions of a function or activity which are performed by the PAS. The On-line/ASPR application discussed in Appendix B thus supports several procurement functions. The specific software which is used by an application is called a *module* (or software module). A module includes the programs and the files which support one or more applications. Thus, a text editor module might support several functions including both the BROKER and On-line/RFP applications discussed in Appendix B.

APPLICATIONS SUPPORTED BY THE PAS

Four New Applications

This section briefly discusses all of the applications which would be supported by the full PAS. As recognized in Appendix E, several of these applications are already implemented in some form within DoD's existing procurement system, and others are in the design stage. However, the discussion will be generic rather than specific because the requirements reflected by the applications are to a great extent independent of any particular implementation. Moreover, the existing software is in some cases not really the software that is best for a particular application. For example, none of the text editors known to us fully meet the human factors requirements of the On-line/RFP and On-line/Proposal applications discussed below.

Four of the applications supported by the PAS have been discussed extensively in Appendix B. However, implementing these four alone would lead to a very incomplete and spotty coverage of the procurement process. Other applications which require new technology or whose payoff is uncertain should also be considered. One application, the Message Service, similar to the current SNDMSG and discussed in Appendix B, can also be supported.

The On-line/ASPR application is an information retrieval system centered around the text of the Armed Services Procurement Regulation (ASPR) and related documents. This application would permit the retrieval of citations from these documents, including citations by cross reference to the documents, by internal cross references, by page and line number and by section organization. The application would also support the capability for updating and modifying the ASPRs to replace the current hard copy ASPR system supported by DoD.

The On-line/RFP application would support text editor and file manipulation modules intended to facilitate the creation, generation, review and publication of procurement documents which are internal to DoD. (Typical documents are work statements,

TABLE A-1

APPLICATIONS SUPPORTED
BY THE PAS

Application Name	Supporting Software Modules
On-line/ASPR	Information retrieval, limited text editor, file handler
On-line/RFP	Full text editor, file handler, support for "smart" terminal, limited FORUM*
BROKER	Information retrieval, file handler
SCOREBOARD	Information retrieval, data capture
Forms Processing	Forms display and checking programs, support for "smart" terminal
Contractors File	Information retrieval, security, forms processing
On-line/Proposals	Same as On-line/RFP plus full graphics storage, security, access trace
FORUM	FORUM, security, access trace
Message Service	SNDMSG & READMAIL plus text editor, file handler
On-line/Procurement Regs	Same as On-line/ASPR plus graphics storage, forms processing
Access Reports	Access trace, security

* Could be supported by SNDMSG, READMAIL and LINK facilities.

RFPs and drafts of contracts.) The application would accept and store new text and comments and changes to old text. It would also have access to a file containing the "boilerplate" text which does not vary from procurement to procurement and would support on-line composition of the text for hard copy printout.

BROKER is a DoD-maintained information system for the procurement of high technology items such as laboratory equipment and electrical and electronic components. BROKER is designed to:

1. Provide users with a complete list of the capabilities and prices of high technology items. This is expected to expedite the procurement of these items, thereby reducing lead times and the possibility of an overstock of obsolescent items.

2. Ensure that all manufacturers whose products are listed on the system would be cited in any request for their items. Manufacturers would be required to provide prices for their listed components and equipment.

3. Incorporate a user feedback mechanism to prevent misrepresentation.

SCOREBOARD is an application for capturing and structuring data on the scheduling of large procurements. SCOREBOARD would make it possible for defense personnel and contractors to see the status of large procurements at any time and would allow the development and maintenance of schedules for reviews and meetings connected with such procurements. Users of SCOREBOARD would be able to ask questions of the form, "who's doing what?" and, "what stage has such-and-such reached?"

Additional Applications Required

In addition to these four applications, others are required by the full PAS. These applications are discussed below.

The Forms Processing application supports the automated input of many of the forms which defense contractors and defense personnel must fill out in the course of a procurement. Under the Forms Processing application, programs would be available to display forms at user terminals, accept input in the appropriate blank spaces, check the input for validity, and file the information correctly. Contractors who input information using this application would be able to append it to submissions of proposals. Data which has not changed since the last submission would not have to be reinput before being resubmitted. Internal forms and documentation could also be supported by this system, with similar advantages. Proprietary data derived from a form could be stored in a private file. Given that the security and privacy features of the PAS work as intended, it is conceivable and desirable that users' inputs be regarded as signed legal documents and users be legally bound by their on-line responses to the forms processor.

The Contractors File would include information provided by contractors through the Forms Processing module and performance information provided by DoD. Thus, a record in the Contractors File would contain a profile of that contractor's past performance, current proposed work, and "vital statistics." The Contractors File could be used to prepare source lists and to obtain other procurement information during bidding. Components of procurement such as quality assurance and subcontractor procurement capability could be handled by subfiles within this file. Not only would records in this file be protected from unauthorized viewing or updating, but a trace would be kept of *all* attempts to access records. If necessary, certain portions of the file could be encrypted.

The On-line/Proposals application would be much the same as the On-line/RFP application. However, it would be used by contractors as well as by DoD. Thus, it would include security, access tracing and graphics modules. These facilities would make it possible for major segments of procurements to be conducted electronically. Following the creation of an RFP or IFB by the Defense Department, bidders would submit proposals prepared using this on-line application. Review, amendment, evaluation, selection, and negotiation could all take place on-line using this application and the FORUM capability discussed below. The graphics capability would allow use of high quality artwork by proposing or bidding contractors. The Access Trace facility would protect proprietary information and provide an auditable record of the procurement. The On-line/Proposal system could interface with SCOREBOARD, the Contractors File and the On-line/ASPR system to minimize file overhead and/or take advantage of their input. All repetitive input from either DoD or its contractors could then be stored only once.

A FORUM-like service would be supported as a separate application on the PAS. This application would provide for both synchronous conferences and asynchronous review of other documents on the PAS. Conferences, with a specified agenda if desired, could take place with a chairman and a parliamentarian without requiring travel by the conferees. Review would take place asynchronously as follows. Each reviewer would have access to a copy of the text to be reviewed. His comments would be recorded and could be kept separate from other reviewers. The asynchronous FORUM could also allow for an iterative review process. For DoD use the security and access trace facilities would be required by this application. The SCOREBOARD application could accept information on users' activities.

The Message Service application supported by the PAS would be similar to the current TENEX SNDMSG service used over the ARPANET. This application is intended to facilitate communication between geographically dispersed DoD activities and agencies. To some extent it would substitute for the full FORUM capability just discussed, especially if added to it were a LINK command enabling direct interviews over an on-line system.

The On-line/Procurement Regulations application is an extension of the On-line/ASPR application discussed above. This application, however, would require graphics storage, and graphics and forms processing capabilities as well. This application's database, discussed in Appendix C, would be perhaps 1.7×10^9 characters in size and would require very large random access memories. This application would substitute for service and command level procurement regulations. It would include Mil Specs, Mil Standards and some Mil Handbooks in its database, necessitating extensive graphics capability, (which may have to be done off-line, limited by the state of the art).

Finally, the access tracing and security system would be able to provide extensive monitoring and reporting of the current usage of the procurement system. The Access Reports application would use this data in several ways. The facility could reconstruct the access history of any data record in the system or of any individual user. This would enable review and audit of procurements after-the-fact and provide evidence of what actually occurred during the procurement in case of a protest. The access reports could also be used in a more general way to show the uses to which system software modules are being put and the activity levels of various files and records. This information could be used by the staff of the PAS to optimize storage allocation and hardware and software design after the system has come into use.

THE PHASED IMPLEMENTATION PLAN

As noted above, the implementation of the PAS will be accomplished in several phases. For reasons which will be apparent below, these have been numbered 1, 1.5, 2 and 3. Phase 1 consists of implementing three applications (On-line/ASPR, BROKER and a Message Service) on existing hardware using available software wherever possible. During this phase, new programming would be confined to pre-processors and post-processors. Pre-processors would massage data into the form required by existing software and post-processors would be used where necessary to make the existing software invisible to users.

Phase 1.5 consists of moving these three applications to new hardware and software intended for the PAS. Much of Phase 1.5 would be devoted to the procurement of the hardware and the development of an operating system to support all future applications. In addition, re-programming of the first three applications would be required.

Phase 2 consists of implementing five more applications: On-line/RFP, Forms Processing, Security and Access Trace, SCOREBOARD and a full FORUM. These applications can still be accomplished using state of the art technology, and build upon the applications implemented during Phase 1. When combined with these applications they support most present procurement functions.

During Phase 3 the final four applications are implemented: On-line/Procurement Regs, On-line/Proposals, the Contractors File, and the Encrypt/Decrypt and Access Reporting functions of the security system. Each of these applications requires new technology or data which are unavailable prior to this phase. In particular, on-line graphics capability is required to support the On-line/Proposals and On-line/Procurement Regs applications.

It is not yet possible to say how much time should be allowed for each of these phases. Scheduling will depend on the difficulties encountered along the way and on the ultimate decisions as to which applications shall be implemented. But we conjecture that the PAS will not be completely implemented before 1985. Under the proposed timetable, Phases 1 and 1.5 would begin within a few years and end by 1980. Phase 2 would run from 1980 until perhaps 1983, while Phase 3 would run until 1985. It is expected that by 1983 the graphics technology bottleneck will be significantly alleviated.

RELATION BETWEEN PROCUREMENT FUNCTIONS AND PAS APPLICATIONS

Table A-2 shows the use of PAS applications by different procurement functions. These functions range over the whole of the procurement cycle discussed in Appendix E of the First Quarterly Technical Report (R-148). Also included as procurement functions are internal functions such as the maintenance of distribution lists, scheduling of procurements, document maintenance and internal conferencing. In addition to the procurement applications listed previously, two additional applications have been included in this table. These are the Operating System and the Miscellaneous Utility programs. Both of these are needed to support the other applications and will be discussed further below.

In the table, each non-blank entry gives the phase of implementation when the specified function will occur. A non-blank

TABLE A-2

USE OF PAS APPLICATIONS
BY PROCUREMENT FUNCTIONS

Procurement Function	Application Name												
	On-line/ASPR	On-line/RFP	BROKER	SCOREBOARD	Forms Processing	Contractors File	Message Service	Full Forum	On-line/Proposals	On-line Procurement/Regs	Security and Access Reporting	Operating System	Misc. Utilities
Establish req't		2	1					2	3	3		1	1
Work statement and PR	1	2	1				1		3	3		1	1
Prepare RFP/IFB	1	2	1		2				3			1	1
Synopsis/advertisement	1	2	1			3			3	3		1	1
Prepare bids or proposals	1				2				3	3	3	1	1
Review proposals									3		3	1	1
Pre-bid/solicit'n conference				2				2			3	1	1
Amendments		2							3		3	1	1
Source eval'n and selection						3		2			3	1	1
Negotiation	1	2	1			3		2	3		3	1	1
Post-award					2	3						1	1
Distribution lists				2								1	1
Scheduling				2			1	2				1	1
Document maint.	1	2							3			1	1
Int'l conferences		2					1	2			3	1	1

Legend: Each non-zero entry gives the phase when implementation of the specified function is to occur.

entry indicates that a particular function will make use of this application and that it will be available by the specified phase. Blank entries imply that a particular function will make only negligible use of a particular application. When two similar applications are entered against the same function, as when the On-line/RFP and On-line/Proposals applications are both shown as being used to prepare RFPs or IFBs, it should be understood that the function will make use of each as it becomes available.

Scanning vertically along the columns provides an impression of the applications' relative importance. For instance, we can see that the first three applications, the On-line/ASPR, On-line/RFP and BROKER applications are more important than the next three or four because they can be used by more functions. Similarly, when they become available, the On-line/Proposals and On-line/Procurement Regs will be extremely useful. Some supporting applications are used by almost all or by all functions. These are the Operating System and the Utility applications, and the Security and Access Reporting applications.

RELATION BETWEEN PAS APPLICATIONS AND SOFTWARE MODULES

Table A-3 illustrates the effect of the phased implementation plan both on PAS applications and on software modules. The top half of the table repeats the phased implementation sequence planned for the various applications. The lower half of the table shows which software modules must be implemented in order to support the applications named in the top half. Thus, during Phase 1 an information retrieval module, a text editor and file handler module and SNDMSG, READMAIL and LINK modules must be implemented in order to support On-line/ASPRs, BROKER and the Message Service.

The table is intended to convey the dependence of the applications and the modules both between themselves and over time. Thus, by Phase 2 all of these modules implemented in Phase 1 are still required. Not shown is the dependence of applications on previous applications through the requirement for large files. For instance, the Contractors File will make use of information

Table A-3

PHASED IMPLEMENTATION PLAN FOR THE PAS

	Phase 1	Phase 2	Phase 3
Application implementation sequence	On-line/ASPR BROKER Message Service	On-line/RFP Forms Processing Security & Access Trace SCOREBOARD FORUM	On-line/Procurement Regs On-line/Proposals Contractors File Access Reporting, encrypt/decrypt
Software module implementation sequence	Information retrieval Text editor/file handler SNDMSG, READMAIL LINK or limited FORUM	Smart terminal support Forms processing Security Access trace data capture Full FORUM	Graphics support Encrypt/decrypt Composition Access reporting Misc. utilities

generated by the Forms Processing and SCOREBOARD applications. The BROKER application will also be used in producing a Contractors File. Rather than create these files *de novo*, implementation of the Contractors File is postponed until Phase 3, when the data collected by the previously implemented applications will be available for file creation.

There is, of course, nothing sacred about the phased plan shown here. It may be necessary or desirable to change the order of implementation, or to implement different software modules earlier or later. For instance, many of the security and access trace features might be implemented during an earlier phase. Once these are installed, the Access Reporting capability could be put up without further difficulties. Also, the implementation of SCOREBOARD could be postponed until the capability for gathering the information which it requires automatically exists within the system. A SCOREBOARD requiring large amounts of manual input would probably not be cost effective.

SOFTWARE MODULES FOR THE PAS

Table A-4 shows the software modules which would be required for the complete implementation of the PAS. Those modules listed under the Operating System could be provided by an existing system or by new hardware or software and the list presented here is not intended to be definitive. But, the software modules listed under Section 2 are required specifically by the PAS and (except in Section 2.9) an attempt has been made to provide a complete list.

The required modules include language compilers and interpreters to be used in writing the other code used by the PAS (2.1). In line with the recommendations on security and privacy, the compilers would be inaccesible to system users. No user code would be executed, and any "languages" used would be executed by interpreters. The file handling system (2.2) is required to manipulate user files, and includes sorting and report generation packages. The file handler would also have to interface with the system security modules, in order to verify the ability of a user to access or modify a file.

Table A-4

SOFTWARE MODULES FOR THE PAS

- 1.0 Operating System
  - 1.1 Scheduler
  - 1.2 Resource allocation
  - 1.3 Storage management
    - 1.3.1 I/O drivers
    - 1.3.2 Audit trail generator
  - 1.4 User terminal control
    - 1.4.1 Communications terminal control
    - 1.4.2 Network control
  - 1.5 Diagnostic and recovery package
    - 1.5.1 System reconfiguration
    - 1.5.2 File recovery
    - 1.5.3 System performance monitoring
  - 1.6 Security
    - 1.6.1 User validation/verification file
    - 1.6.2 Encryption/decryption
    - 1.6.3 Storage protection
  - 1.7 Accounting
  - 1.8 Command language processor

- 2.0 System Software Modules
  - 2.1 Language compilers and interpreters
  - 2.2 Data management (file [illegible] command language)
    - 2.2.1 Tape/disk file cr[illegible], [illegible]eletion, update
    - 2.2.2 Sorts
    - 2.2.3 Report generators
  - 2.3 Information retrieval system
    - 2.3.1 File definition
    - 2.3.2 File maintenance
    - 2.3.3 File search (command language processor)

CONTINUED

Table A-4 (cont'd)

2.4 Text editor(s)
2.4.1 Basic file change commands
2.4.2 Support for "smart" terminal
2.4.3 Composition (typesetting) commands
2.5 Forms processor
2.6 Graphics processing
2.6.1 Input processing
2.6.2 Retrieval/generation software
2.7 FORUM facilities
2.7.1 Synchronous conferencing
2.7.2 Asynchronous (review & comment)
2.8 Access trace processor
2.8.1 Report generator
2.8.2 Data capture
2.8.3 Audit trail
2.9 Miscellaneous
2.9.1 TTYTST
2.9.2 HELP, EXPLAIN
2.9.3 LINK
2.9.4 SNDMSG and READMAIL
2.9.5 KWIC index generator

The information retrieval system (2.3) and the text editor system (2.4) form the core of many PAS applications. The submodules listed in these two sections would not all have to be written together. For instance, the smart terminal support and composition commands of the text editor could be included during Phase 3. Only the basic file change commands would be used during Phases 1 and 2. Information retrieval systems, such as SPIRES or the Mead/Avionics Central, and text editors, such as NLS, TECO and WYLBUR, are also adequate for Phase 1, although each of these has some limitations associated with its terminal requirements or human factors.

The Forms Processor module (2.5), the Graphics Processing module (2.6) and the FORUM facilities (2.7) each support a separate application within the PAS. Two submodules of the Graphics Processor support the input of graphics, coding, and storage, while the other supports the retrieval or generation of graphics for on-line use. The FORUM features can be similarly decomposed into a synchronous conferencing module and an asynchronous review and comment module.

Finally, the Access Trace Processor (2.8) and several miscellaneous routines (2.9) are used in the PAS for a variety of purposes. Access trails can be generated with respect to users or files or programs. Normally these trails are dumped off-line and a report generator program is used to reconstruct them in a coherent fashion. The audit trail facility, however, should permit tagging particular users or transactions so that they will print out in real time at a particular secure terminal. The miscellaneous submodules are intended to give a non-inclusive list of some features which the PAS would probably have. Abbreviations are based on TENEX and other contemporary time-sharing system commands.

A brief comment is in order on the operating system implied under Section 1.0. The emphasis here is on a multi-programming and/or multi-processing time-shared system. The system would have access both to local terminals and to a network and could provide secure reliable operation and efficient management of system resources. Hardware for this design was discussed in Appendix I of the First Quarterly Technical Report (R-148).

CONCLUSION

The plan presented by this appendix is really no more than a sketch of the full implementation plan. The appendix has however, tried to illustrate the interdependence between procurement functions, PAS applications and the software modules which support the applications. To do this completely would have required a greater level of detail than is possible at this point. Further knowledge of the proposed software, sizes of the database, and the structure of the procurement functions themselves would be needed before a sufficiently detailed plan could be developed.

By implication, this information will have to be generated prior to Phase 1. Indeed, a Phase "0 ", during which development studies and detailed planning are done, is a necessary part of PAS implementation. Phase 0 studies could be started quickly and require perhaps a year to complete. During this time preliminary hardware and software would be selected for the Phase 1 implementation. Given this environment, and a better understanding of the first procurement functions to be automated, another implementation plan would be designed and preliminary specifications produced.

Some of the largest uncertainties associated with planning for the PAS are the nature of the activities carried on by each procurement function. Detailed knowledge of the current information flows and organizational structure is required in order to merge the new system with the old. Therefore, during Phase 0 considerable study of a particular procurement office (and cooperation by that office) would be required, which is beyond the intent of the present contract.

APPENDIX B

PROPOSED APPLICATIONS FOR A PROCUREMENT AUTOMATION SYSTEM

by

Carson E. Agnew

INTRODUCTION

This is one of two appendices on the applications software requirements for the Procurement Automation System (PAS). Appendix A, the companion to this paper, discusses the general requirements of the PAS and outlines a development plan to implement certain software modules before others. This appendix discusses in detail four functions of the PAS which appear to have exceptional merit.

Applications

The four applications, in order of their discussion, are:

1. On-line/ASPR -- A system for searching ASPR and related documents.

2. On-line/RFPs -- A system for preparing, editing and issuing work statements, RFPs, IFBs and other procurement documents produced by DoD.

3. BROKER -- An information system for the procurement of high technology items.

4. SCOREBOARD -- A schedule monitoring system for large procurements.

The remainder of this appendix discusses each of these applications in turn. Appendix A deals with the software requirements of these and other applications, and with quantifying some of the expected costs and benefits.

The applications discussed here were among those conceived by the Cabledata Associates research team during the earlier phases of its work on this contract. Other applications, not discussed below, do not seem as attractive as these for one or more of the following reasons:

. The application required hardware or software technology which was too far beyond the current state of the art.

. The application did not appear to have readily identifiable benefits, even though the capability provided would have been attractive and technically feasible.

- Implementation of the application required extensive reform of the current procurement system. (Since acceptance of the PAS by those currently doing procurement is essential to its success, these applications must be postponed until the reforms are made.)

- The application was better done after implementation of other applications.

Although some of the four applications discussed in this report require procedural changes, these do not seem to be extensive enough to jeopardize acceptance. Each can be implemented with state-of-the-art hardware and software and, although they have some software in common, none is dependent on the implementation of another application for its operation. In addition, each should provide tangible and intangible benefits to DoD which will offset its cost. In particular, these four applications promise to materially speed up the procurement of expensive or high technology items, thereby producing considerable monetary savings and enhancing the effectiveness and timeliness of the equipment procured by the Department of Defense.

The first software packages developed for the PAS should be used to implement these applications. Their early success will provide the justification for implementation of other procurement functions.

APPLICATION 1: ON-LINE/ASPR -- A REFERENCE SYSTEM FOR PROCUREMENT

The current version of ASPR (Armed Services Procurement Regulations) is the basic reference document for the Defense procurement community. Both contractors and DoD procurement officers base their day-to-day decisions on ASPR and the regulations subordinate to it issued by the several services and their commands. The costs associated with maintaining a current uniform version of ASPR worldwide are therefore quite large. For example, the direct cost to DoD of revisions 8 and 9 to ASPR (conducted during a seven-month period in 1969) was $482,000 (72 man years).* The cost to

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Report of the Commission on Government Procurement, vol. 1, December 1972, p.33.

contractors must have been of roughly the same magnitude.*

Even with a set of up-to-date ASPR, the procurement officer or contractor still finds it difficult to use. ASPR has no index, and it contains a number of cross references to other documents (such as Mil Specs) which also must be obtained and kept current. These documents in turn contain no index and make cross references to other documents, and so the size of each complete file increases until it fills at least a five foot shelf. The user whose collection lacks a referenced document has no way to evaluate its relevence *a priori* and must either hope it is irrelevant or spend time to find it and its antecedents.

This hardcopy information system was appropriate before automated methods were available. Although it is still difficult to maintain large files on-line,** the technology of information storage and retrieval appears to have reached the point where it is economic to keep those documents most frequently referenced on-line, and to access them remotely. The On-line/ASPR application would perform this function.***

Indexes

The On-line/ASPR application would replace the present hard-copy ASPR system by a database consisting of the text of ASPR and other documents most frequently referenced in it. Accompanying the text files would be indexes covering:

- Section organization
- Keywords in the text (plus a thesaurus)
- Internal and external cross references
- DoD forms by subject and form number

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*These revisions involved 1664 pages of ASPR. Each volume would require about 90 minutes to update if it were done all at once, but perhaps 3 to 5 hours over the seven-month period. If the employee doing the updating were paid $5.00 per hour, each volume cost $15 to $25 to update. For a circulation of 20,000 copies this update cost between $300,000 and $500,000 which is roughly the DoD cost.

**See Appendix C, "Size and Cost of Static Files for a Procurement Automation System."

***While ASPR's exist on-line today in the Mead Avionics Central system, its access is via special purpose terminals. What is proposed here is complete widely available access from any general purpose terminal, and as part of a fully integrated system.

These indexes would make it possible to find quickly a requested passage or all relevant passages. It would be possible to quickly trace cross references and their antecedents. Information about documents referenced but not stored on-line could be maintained, enabling the user of the on-line system to receive:

. An abstract of the referenced document

. The location of Federal repositories which have the referenced document

. Directions for ordering a hardcopy of the referenced document.

These features would enable users to browse or search the files for the relevant regulations. In conjunction with a text editing system, portions of text could be copied for later reference or for inclusion in a report or memo composed on-line. An on-line text editor would also facilitate preparation of new material or updates to the database.

Costs and Benefits

Because infrequently referenced documents would not be stored, the database could be much smaller than the file sizes estimated in Appendix C. Also, since the ASPR documents seldom include graphics (except for boxes which are drawn around forms), the difficulties with storage and retrieval of graphics would not need to be confronted.

Table B-1 illustrates the creation and storage costs associated with the proposed on-line database. It assumes that the files associated with the ASPR will be four times as large as the size of the ASPR itself, for a total size of 5×10^7 characters, and that the index volume will equal the size of the file. All 10^8 characters will thus occupy roughly half of a 3330 disk pack.* (During database creation an "infinitesimal lookahead" algorithm like the one described in Appendix C can be used to determine its correct size.)

The most uncertain item listed in the table is the file creation cost. This will ultimately depend on the specific hardware and

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*To ease retrieval, however, it will probably be advisable to keep the file and its indexes on several packs.

Table B-1

INITIAL DIRECT COSTS OF AN ON-LINE/ASPR DATABASE

Data Entry (OCR)*	$ 6,945
File Creation Cost (computer time)**	10,000
Storage***	2,400
TOTAL	$19,345

Notes:

*0.0139 ¢/character. See Appendix C.

**Estimated for typical SPIRES files at .01 ¢/character, excluding cost of SPIRES software.

***3×10^{-4} ¢/bit (double-density 3330-type disk storage) software used for On-line/ASPR. The $10,000 charge assessed here is based on a judgmental estimate of the cost of creating a small file on the Stanford SPIRES system.* In view of the uncertainty associated with this figure and the evident low cost of OCR, it would be useful and inexpensive to create a fragment of the On-line/ASPR file on current database management or information retrieval systems. This experiment would benchmark the costs and performance of these systems much more accurately than is now possible.

The cost estimates shown in the table represent the first cost of creating the On-line/ASPR files. As such they do not include maintenance costs or overhead costs. Further they include no charge for the software costs of operating systems or information retrieval systems. These costs are normally recovered in the computer charges billed to the user.

Table B-1 indicates that the cost of creating the on-line database from the printed version will be relatively small if a general purpose information retrieval system similar to SPIRES is available. Using OCR technology to produce machine readable input and storing the resulting files on disk will have a direct cost of around $20,000. This represents a surcharge of between $5.00 and $8.00 per hour which can be spread over all of the system's users.**

If there is an average of 5 users per hour this cost of roughly $6.50 per hour becomes $1.30 per user hour. This cost is an order of magnitude lower than current time-sharing rates of $15 to $50/hr. When these costs are included it is unclear whether or not the on-line system will actually cost less than the hardcopy system. The former's creation and maintenance costs are lower than the latter, but the cost of on-line access may be high enough to

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*SPIRES (Stanford Public Information REtrieval System) is an on-line general purpose information system developed at Stanford University and implemented on an IBM 360/67.

**The hourly figure was derived by amortizing the initial cost of $19,345 over five years at a 10% discount rate. Assuming 12 hour/day availability, 250 working days per year gives $1.65 per hour; 24 hour/day availability, 365 days per year gives $.60 per hour. To this must be added a maintenance cost, which was assumed to be equivalent to roughly one man-hour per machine hour at $5.00 per hour.

vitiate this advantage. However, the on-line application should provide additional benefits in the form of increased effectiveness, such as:

- Assurance that everyone has a *timely copy* of the regulations.
- *Consistent citations*, to reduce differences of interpretation between DoD and its contractors.
- *On-line access*, to ease inter-agency agreement on a uniform regulation. This can ultimately reduce the amount of duplicate information stored and maintained both on-line and off-line and simplify its updating and maintenance.
- *Adequate indexing*, to make it possible to adhere to the various special requirements of the procurement regulations and to enforce compliance.
- *On-line storage*, to make it possible to include excerpts from the regulations in memoranda or reports without having to recopy the text. (This feature is discussed further under the On-line/RFP application, below.)

APPLICATION 2: ON-LINE/RFP -- A SYSTEM FOR PREPARING INTERNAL PROCUREMENT DOCUMENTS

This application supports the creation, editing, review and final preparation of internal procurement documents such as

- Work statements (WS)
- Procurement requests (PR)
- Requests for proposal (RFP)
- Invitations for bid (IFB)
- Negotiated contracts.

As discussed in Appendix E in the ARPANET Management Study, First Quarterly Technical Report (R-148) these documents form the heart of the procurement cycle within DoD. The work statement and the purchase request are prepared by the agency or command desiring the item to be procured. This effort requires the cooperation of the technical personnel at the agency and the personnel at the procurement office designated. Budgetary consultants and outside experts may also be used.

The work statement forms the core of future drafts of the RFP or the IFB. Each of these documents is drafted by the procurement office and contains numerous "boilerplate" and routine text sections in addition to the text which is applicable to the particular procurement in question. The RFP or IFB may also require editing and redrafting after a review by DoD technical personnel or in light of comments by potential bidders.

The final RFP or IFB in turn becomes the basis for a draft of the contract negotiated between the winning bidder and DoD. Further revisions are possible at this stage, after which the final contract is signed.

Much of the same text is reused throughout the course of a procurement, beginning in the draft work statement and ending as part of the final contract. Also, the boilerplate is reused over the course of many different contracts. Yet considerable expense is incurred retyping and redrafting text, and locating and including the required boilerplate clauses in each contract. Further costs arise when conferences must be conducted or when drafts must be circulated for comments, and then edited into a new draft.

Capabilities

The On-line/RFP application of the PAS is intended to eliminate the duplication of paperwork which the present hardcopy-based system entails. Its several software packages would allow:

- Creation and editing of text on-line
- Inclusion of boilerplate which is stored on-line
- Synchronous conferencing and asynchronous review of draft documents
- Convenient preparation of final text for hardcopy distribution to contractors.

The application is intended for internal use by DoD. It is not envisioned that bidders or contractors would have automatic access, or would prepare and submit bids and proposals using the system; nor would it be used during the source selection and evaluation phase of a procurement. Hence, extensive access trails would *not* be required. However, in conjunction with the SCOREBOARD application discussed below, this application would support a facility for automatically recording who has looked at what documents and what review or approval stages a document has traversed.

The text creation and editing capabilities of the On-line/RFP application would be supported by a text editor system and a convenient terminal system. The text editor should have some of the structured text capabilities of systems such as NLS which would allow boilerplate and "fine print" to be referenced without necessarily appearing when the text is being composed or edited. The terminal should probably be a "smart" system which incorporates considerable local editing capabilities and some local storage. Experience has shown that the human factors aspects of most current text editors are unsatisfactory--given the choice, secretarial staff prefer a typewriter to a text editor because the former is faster and more flexible than the latter. A terminal with the speed and flexibility of a typewriter would probably require a microprocessor and some local memory to support an extended character set; half spacing; and editing features such as backspace, back-word, and backline deletion.

An important feature of the On-line/RFP system would be its ability to reference boilerplate text on-line and to share a single master copy of the boilerplate text among a number of documents. This could be accomplished by embedding an information retrieval system within the text editor system. Users could then search a file of boilerplate using keywords, section numbers and so on, and "copy" the relevant portions of the text located as a result of the search into their file. The copy need not physically occur, but could be implemented by a pointer system from the text to the master file. This master file will considerably overlap the On-line/ASPR system files, and the same information retrieval software could be used in both applications.

These two features would make it possible to move from the draft work statement at least to the RFP stage without retyping unchanging portions of text at any time. These features become more valuable when it is possible to circulate a draft stored on-line for comments or corrections and when conferences between different individuals concerned with the document can be conducted on-line. In the On-line/RFP application the features can be thought of as *review* and *conferencing* respectively. The *review* is conducted asynchronously and should support either signed or anonymous reviews. It should also be possible to keep one reviewer from seeing another's comments before he has himself commented. The *conference* is conducted synchronously, and is intended to substitute for travel and face-to-face conferencing during the procurement. Both these features could be supported by a system such as FORUM, or a more specialized system could be designed. The system should be able to reference the text files for copies of the document, and to interface with the text editor to collect comments from its users. Consistent use of the same command set will make the irregular or novice user of the system more comfortable, as would use of the proposed intelligent terminal.

When a draft is ready to be circulated to potential bidders as an RFP, it must be prepared in hardcopy form. This task can be facilitated either by features of the text editor or by a separate report preparation feature of the On-line/RFP application. This feature should allow formatting of the text for several type fonts (implemented by a larger character set) and for tables and figures prepared off-line. The prepared text can be printed onto pages suitable for immediate reproduction and distribution.

Costs and Benefits

The costs and benefits of this application are easier to point out than to quantify. Software costs for the features of this system may be large, even though the technology now exists. Similarly, terminal development and production training, conversion and translation costs are not small.

The benefits of the system accrue principally from the shorter lead times which could be achieved in procurements. Currently DoD procurements are costly and slow. This occurs in part because the procurement regulations are designed to ensure fairness to competing bidders and to protect the government from fraud. But their effect is to slow the procurement process and to focus the attention of procurement personnel on the regulations instead of on the items being procured and their usefulness to the Defense Department's goals. Further difficulties arise because DoD is a very large, geographically dispersed organization. This raises the time and money cost of coordinating a complex procurement.

The On-line/RFP application can help to alleviate these problems in several ways. First, it can enable the Defense Department to shorten the lead times required to prepare a procurement. The mere fact that only a small portion of each document must be retyped each time will save some time. Second, time can be saved because the on-line nature of the system makes it possible to perform tasks in parallel which were previously performed in series. Reviews, conferences and editing can now take place simultaneously, focusing on a single copy of the document. By allowing private or anonymous reviews, and by keeping reviewers from seeing each other's comments, different branches of the Department whose approval and comments must now be secured one-at-a-time can work in parallel without interfering with each other.

It might be possible to measure the dollar benefit of shorter procurement lead times in the manner to be discussed below for the BROKER application. But it is extremely difficult to evaluate in quantitative terms the effect of a system which focused attention on the goals of the procurement instead of the regulations governing it. The On-line/RFP system should have this effect because when it is used the regulations are literally pushed down to the bottom of the file. Only the new text, relating to the current problem, will actually be of interest.

APPLICATION 3: BROKER -- AN AUTOMATED PROCUREMENT SYSTEM FOR HIGH TECHNOLOGY ITEMS

The BROKER function in an automated procurement system is intended to promote the efficient and effective procurement of high technology items, defined as pieces of hardware or software characterized by one or more of the following attributes:

- Rapid technical progress
- High unit cost
- Absence of standard features

Typical high technology items are digital computers, integrated circuits and laboratory test equipment.

These items and others like them represent a continuing procurement problem. This problem arises because the present procurement system is not equipped to handle high technology items in a manner that assures the government high quality and low cost.

The present day generation of procurement systems have been to a major extent designed either to provide items at the lowest cost, or where cost is not the only criteria, to balance effectiveness against cost. Safeguards built-in throughout the system are intended to protect the government from exploitation and to ensure that all potential suppliers receive equal treatment.

These procedures and safeguards work poorly when high technology items must be procured because they prevent timely procurement and are inflexible in dealing with new items. Because it is impossible to place orders for high technology equipment in a timely manner, the rapid rate of technical progress almost ensures that the government will receive obsolescent items. If larger orders are placed to compensate for the ordering delay, rapid technical change implies that new and better material will be available before stocks of the old are exhausted. This necessitates either scrapping of the old material or use of old items until newer ones are purchased. These alternatives are forced upon the government because it cannot procure small numbers of high technology items rapidly with existing systems.

Items involving high unit cost and non-standard functions are difficult to handle routinely using existing procurement systems. Too much time is often required to write and implement a specification; nor is doing so worthwhile if premature standardization will freeze the development of the technology. High cost and infrequent demand may necessitate the use of time-consuming procedures such as formal advertising, even when it is known beforehand which firms can possibly provide the needed equipment. Basic ordering agreements, Federal Supply Schedules or other procedures are impractical because of the rapidly changing specifications.

BROKER is an information system which matches DoD buyers of high technology items to private suppliers. Its purpose is to maintain current information on the costs and capabilities of high technology items produced by many suppliers. Emphasis would be on timely content and ease of search of the database, thereby reducing the time required to procure an item. BROKER should list virtually all firms capable of supplying an item. This would make it possible to expedite the procurement process by ensuring that all eligible firms are considered.

BROKER would provide an interface to an on-line text editor and a file of boilerplate of the type discussed in the On-line/RFP application. These programs would make it possible to prepare work statements, IFBs or RFPs which would match *current* technology and select firms able to respond quickly.

Implementation and maintenance of BROKER would require constant monitoring of the relevant technologies. Although a DoD group would be responsible for the completeness of the database, contractors would be encouraged to contribute product information. If BROKER proves a useful service, contractors will probably contribute information willingly, as it will be in their own interests to do so.

"Market" Feedback

BROKER could also incorporate a "feedback channel" from DoD buyers. This would provide previous users of an item the opportunity to comment on its usefulness and on the supplier's performance (e.g., adherence to promised delivery dates). Other DoD personnel would be able to access the feedback comments, and each contractor would be informed and allowed rebuttal.

The automated portion of BROKER is organized like a large and well-indexed catalog. Software is therefore required to create and update a file and its indexes, and to search the file for many users at once. Typical records in the file might contain the following elements:

- Part number (s)
- Item description
- Manufacturer
  - Name
  - Address
  - Name and telephone number of sales representative acquainted with item
- Item price (s)
- Lead time or date available
- Special or optional features
- Warranties, financing items, insurance, etc.
- MIL approvals or QPL status
- Feedback comments and rebuttals

It should be possible to search the file using combinations of the following indexing terms:

- Part number
- Item description (keyworded)
- Lead time and date
- Manufacturer name

The system should also be able to supply a list of items similar to a specified part -- possibly on a brand-name-or-equivalent basis.

The update and creation tasks of the automated system could be performed either on-line or off-line. The search task should probably be implemented on-line and should be accessible via a computer network. In this way the staff charged with maintaining the database could be centralized while the users could be scattered throughout the nation. On-line search capability would make the system accessible to designers and other technical personnel who are only peripherally concerned with procurement, and so are unwilling to wait for off-line service.

Data Management

Collecting the information used to update the database is the most important task of BROKER, and it is the one which must be performed manually. This task really involves three subtasks:

1. <u>Data collection</u>. This task involves searching trade journals and other literature, and obtaining catalogs from manufacturers.

2. <u>Data solicitation</u>. Manufacturers themselves should be invited to contribute information about their products to the database. The solicitation task attempts to inform as many manufacturers as possible of the existence of BROKER and to facilitate contribution of product information.

3. <u>Data verification</u>. Whether information is collected by DoD personnel or contributed by manufacturers, some or all of it must be verified. In particular, prices and delivery times must be confirmed in some binding fashion with the manufacturer. The verification task provides this function.

Several other tasks must be performed manually. These include solicitation of feedback on manufacturers and/or rebuttals to feedback, preparation of manuals for use by DoD personnel using the system, and monitoring the uses to which BROKER is put.

These tasks require a staff technically trained in the data collection task, especially in recognizing important new items. Such people should serve relatively short terms, because the technical skills which make them valuable will atrophy if they are not continually refreshed. Such people are unlikely to be found either in the Civil Service or the military. Civilian personnel are typically interested in a career in one area, not in short term appointments. Military personnel, while used for short term service, are not trained as design engineers. This problem will have to be solved if BROKER is to provide a truly effective service.

<u>Potential Benefits</u>

BROKER's major benefit will be to shorten the lead time required to procure high technology items. The quantitative benefits can be bounded from below by viewing it as an inventory and maintenance problem, i.e. any reduction in the delay saves interest charges on the cost of inventory and procurement office overhead. The argument applies equally to government and to business, because government spending is financed by taxation or debt which diverts funds from the private sector.

As an illustration of potential savings, consider the laboratory electronics and electrical equipment stocked by the Defense Supply Agency's commands. In FY 1971 the dollar volume of spending for these items was $188 million.* If BROKER could cut six months from the lead time of an average item in this group, it would save 9.2 million per year at a 10% discount rate.** The figure for a one year saving in lead time is almost $18 million.

In addition to these cost savings, BROKER will make it possible for DoD to order components which are at the edge of the state of the art instead of a year of two behind it. In electronics this seemingly slight temporal difference conceals a large difference in performance. The shorter lead times will either allow DoD to meet its requirements at lower cost or to perform more functions using the same budget.

The BROKER system can also be expected to promote fairer competition among contractors. By ensuring that a contractor's product will be brought to the attention of a potential buyer, the system provides contractors with a powerful incentive to keep their information current. The feedback facility prevents them from exploiting the system by misrepresenting price, delivery or performance information. Here it is difficult to quantify the cost savings which such an approach might achieve. Since the application in a sense replaces the formal advertising procurement procedure, we conjecture that the 25% savings over sole-source procurement associated with formal advertising*** would accrue in this case as well.

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*Source: *Report of the Commission on Government Procurement*, vol. 3, p. 91. The categories are for Federal Supply Groups 59, 61, 66 and "other" items stock by the Defense Electronics Supply Command.

**United States Office of Management and Budget, Circular A-94 "Discount Rates to be Used in Evaluation of Deferred Costs and Benefits," November 15, 1971.

***Subcommittee for Special Investigations, House Armed Services Committee, "Review of Army Procurement of the Light Observation Helicopter," 90th Cong., 1st Sess. (Comm. Print 1967).

An interesting extension to BROKER would allow its use by contractor design engineers and purchasing agents. This extension would allow searches by device type with a list of qualifying attributes. This type of search would be considerably more difficult and resource consuming than a search by manufacturer's or generic part number. It is not intended to give spec-sheet level of detail, but to provide a list of part numbers which could be used as inputs to the simpler search to obtain a manufacturer's representative telephone number, who would provide the additional data.

These services would supplement, and possibly supplant, presently available general purpose catalogs such as Electronic Engineers Master, Electronics buyers Guide, D.A.T.A. Books, Thomas Register, etc.

Opening the BROKER system to contractors as well as to DoD would of course greatly expand its use. But because the extended service would reach a significant fraction of the national market, a large part of the cost of the service could then be borne by the suppliers whose products are in the database.

APPLICATION 4: SCOREBOARD -- A SCHEDULE MONITORING SYSTEM FOR LARGE PROCUREMENTS

The final of the four new applications proposed for the PAS is a schedule monitoring system and/or calendar directory for large procurements. SCOREBOARD would maintain two coordinated indexed files for internal and external use. The files would show the status of each contractor's current and proposed work and the schedule for its next phases. Names of contractors and their personnel, and of DoD agencies and their personnel would be maintained in a second file, so that it would be possible to ask "what's so-and-so doing?" as well as "who's doing such and such?" Both DoD personnel and contractors would be able to access and update portions of the file. SCOREBOARD would thus enhance coordination of a large procurement project, as well as its subsequent management.

Capabilities

Typical file contents might include the following elements:

- . Contract file
  - Contract title and abstract
  - Contractor name and address
  - Principal investigator name and address
  - Milestones and reporting dates
  - Budgeted and year-to-date cost
  - Pointers to related contracts
  - DoD reporting agency and PCO
- . Name file
  - Name and position
  - Affiliation/employer
  - Contracts associated with this individual
  - Scheduled reporting dates
  - Address and phone number

In the name file, the contract associations would be used to point to the contract file. Scheduled reporting dates would include dates on which either an internal or external decision must be made. (E.g., a staff member's record would contain the date when an internal evaluation was due. His superior's record would contain a date for making the recommendation officially.)

The SCOREBOARD could be supported by a special purpose information system or by the system used in the On-line/ASPR and BROKER applications previously discussed. It could, if desired, interface with a PERT or other planning package, so that changes in schedules could be reflected in the PERT model. If this were done, information currently required to maintain the PERT model could be put to immediate practical use by updating the SCOREBOARD files. (Alternatively, we might regard the updating information as "free" to SCOREBOARD if it is collected for use in PERT anyway.)

From the contractor's point of view, a SCOREBOARD would relieve some of the uncertainty now associated with government work by making it possible to see when a decision is made and by whom. Of course, it will be necessary to protect part of the files and certain portions of records so that proprietary information (such as contract volume) or competitive information cannot be unintentionally revealed. Authority to update a file could require the simultaneous presence on-line of authorized and authenticated representatives of DoD and the contractor.

The additional cost of SCOREBOARD if the other applications discussed in this working paper are implemented should be quite low. The text editor and information retrieval software needed for these activities can be used for SCOREBOARD, provided that parallel file capability is included in the retrieval system. Maintaining the file will be the highest cost component and this as noted, may share information already collected and put into a machine readable form for other purposes. Furthermore, on-line copies of RFPs and procurement requests are excellent data sources for the initial SCOREBOARD records.

SUMMARY

The four new applications discussed in this working paper are intended to enhance the effectiveness of the procurement process and/or save on procurement costs. The underlying theme is that the current procurement cycle was developed before automated information technology was available. Now that this technology has matured sufficiently, certain procurement functions can be done better or less expensively on-line. These functions include:

- Searching voluminous files of procurement regulations,
- Writing internal procurement documents,
- Keeping up with rapidly advancing hardware technology in areas of importance to the nation's defense, and
- Managing a large procurement efficiently.

Other functions, such as the on-line maintenance of specifications and the on-line preparation of contractor proposals, are not yet worth doing because of the state of current information technology. As the technology advances they will become feasible, as is discussed in Appendix A, the companion to this paper. The above four functions, however, *can* be implemented now and promise significant benefits.

APPENDIX C

SIZE AND COST OF STATIC FILES FOR
A PROCUREMENT AUTOMATION SYSTEM

by

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INTRODUCTION

This appendix considers the sizes of the static files proposed for the Procurement Automation System (PAS). In addition, it attempts to estimate the costs of creating the data base in an on-line environment, and to foresee some of the advantages and difficulties in having almost all procurement-related documents on-line. It concludes that these files are roughly 1.7×10^9 characters in size, of which about 10^9 characters are not duplicated. Although recent advances in OCR technology make it possible to cheaply convert text into machine readable form, comparable ability to handle graphics is currently lacking. For this reason it does not appear possible to keep all procurement documents on-line. However, it appears to be practical and useful to keep a smaller file of high level documents on-line. This file would be perhaps on the order of one-twentieth the size of the full file, say 5×10^7 characters.

ESTIMATING THE SIZE OF STATIC FILES FOR PAS

Many of the files maintained on PAS will be relatively static in nature, consisting of manuals, handbooks, regulations and other procurement-related documents. When stored with their indexes these files will be quite large, and hence costly to store. In order to find out how costly it will be to store and search these documents on-line we must have some rough estimates of the sizes of the files and their indexes.

The estimates discussed in this working paper were developed by measuring the documents stored in the Stanford University Government Documents Library. Stanford is an officially designated repository for Federal documents, and its collection of publicly available documents is reasonably complete. Stantord does not, however, have any of the internal documents which are used by the Commands.

The sizes of these documents are based on the Report of the National Commission on Procurement, Vol. 1, (Fig. 2, p. 34) and Vol. 3, pp. 19-20.

Table C-1 of this paper shows the thickness of a sample of the documents. The last three items (Federal Item Identification Group handbooks, Army Technical manuals and Army Materiel Command pamphlets) are probably irrelevant to major systems procurements. For instance, the Federal Item Identifications are used for logistical purposes (they describe a vast assortment of items in standard, structured format), but are not likely to be used for procuring large items.

ESTIMATING THE NUMBER OF CHARACTERS PER DOCUMENT PAGE

In an average ASPR page, each line is 12.6 cm. wide and contains 80 characters. There are 48 lines to the page, plus about 40 characters of header information. Thus, a page can contain as many as 3880 characters. Paragraphing and indented lists appear to reduce this by ten per cent, so we may say that a page of the ASPR contains 3500 characters. However, the largest page of ASPR sampled contained about 5000 characters because of small print. We will use 4000 in this report.

Since some procurement documents are typewritten rather than typeset, similar estimates have been made for other formats, as follows:

. One page of a Defense Procurement Circular = 2400 characters.

. One page of a Dept. of Commerce NTIS bulletin = 2000 characters.

These two items were chosen because one was typewritten in elite (12 characters per inch) and one in pica (10 characters per inch), and both used U.S. government standard size paper (8" x 10-1/2").

It was determined by measurement that there are roughly 95 sheets of offset paper to each centimeter of thickness.

ESTIMATING THE NUMBER OF CHARACTERS IN THE FILES

Table C-2 presents estimates for the total size and number of characters in the static files. A two-step process was used to

TABLE C-1

SIZES OF SOME REPRESENTATIVE

PROCUREMENT DOCUMENTS

TITLE	THICKNESS, CM WITHOUT COVERS	REMARKS
ASPR	14	
Mil Standards	152	
Mil Specs (all types)	574	Restricted access
Mil Handbooks	71.2	
Defense Procurement Circulars	1.6 / yr.	
Re-negotiation Regulations	11.4	
Army Material Command Procurement Regulations	68.6	
Command Level Documents	77	
Federal Item Identification Group Handbooks	399	Used in logistics applications
Army Technology Manuals	425	Of doubtful relevance
Army Material Command Pamphlets	122	Of doubtful relevance

TABLE C-2

ESTIMATED FILE SIZES

DOCUMENT	SIZE (X 10^6 CHARACTERS)
ASPR	10
DoD High level documents	617
Mil Stds	115
Mil Specs	436
Mil Handbooks	54
DPC's (prev. 5 yrs.)	3
Re-negotiation Regulations	8
Armed Service Level Documents	168-213
Regulations	156
Instructions and Circulars	11-57
Command Level documents	266-7600
TOTAL	1062-8441

obtain the numbers displayed. First, the thickness was computed for each Command level, using the thicknesses estimated in Table C-1, or subjective estimates where thicknesses were unknown. An allowance was made for the fact that there are three services, each with local additional procurement regulations and instructions; and that each service has several Commands which do procurement and issue additional instructions. The centimeter-to-character conversion factors developed in the last section were then applied to produce the table.

As can be seen by looking at the grand totals, the static files of the PAS must be prepared to handle between 1.2 and 2.1 billion characters or about 1.7×10^9 characters in all. Considerable uncertainty remains, however, because only the sizes of the higher level files are known with any accuracy.

Notice that the estimates do not distinguish between text and graphics in estimating the size of the data base. ASPR itself contains almost no graphics, except for boxes used on the forms in Vol. 4. However, documents such as Mil Specs contain a high proportion of graphics to text. Special facilities (e.g., computer-retrieved microfiche and facsimile transmission) will be required if graphics are to be handled adequately.

COMMENTS

The size of the files, if all of the documents listed in Table C-2 are included, is quite large. Including indexes (which can equal the data in size), they could run 3.4×10^{10} bits. However, much of this size is accounted for by Command and Service level documents. It is suspected that there is a great deal of duplication contained in these documents. This duplication made sense before on-line storage and retrieval was economic, because it was more efficient to let each agency have its own regulations than to coordinate changes to a uniform set of rules among a large number of agencies.

This justification does not hold once an on-line system is used. In that case it is possible to maintain one copy of the standard text and include only the amendments required by each agency.

Furthermore, because of the features included in PAS, it may be possible to unify the regulations in a way not possible before automation. The text retrieval and editing capabilities of PAS would make it easy to locate and edit a draft of the final uniform document, and the conferencing capabilities would make it easy to gather comments from the Commands affected by the change.

If we assume that duplicate text can be eliminated from the PAS data base, it is possible to re-estimate the file sizes. This is done by assuming that one copy of the regulations is kept for all the services and that the Commands of each service likewise share text.

The text of the amendments is assumed to be equal in size to the single copy. In this case the data base would contain between 9.51×10^8 and 1.40×10^9 characters. This is roughly 70 per cent of the file size estimated in Table C-2. Thus, reducing the redundancy of the procurement documents at the Service and Command levels would save almost one-third of the creation and maintenance costs of the file. If the PAS were used to eliminate redundancy after the documents were input, almost one-third of the cost of maintaining the file would still be saved.

DECIDING WHAT TO INCLUDE IN THE FILE

It may be unnecessary to put all of the documents into the on-line file. Some will be referenced or consulted so seldom that on-line maintenance will not be cost effective. At this time, it is impossible to estimate which documents may be omitted for these reasons. However, the inverted file indexing structure which will be imposed on input documents can be used to great advantage in determining when not to enter a document. The algorithm would work as follows:

1. Documents, as they are put on-line, are indexed by several elements, including internal and external cross-reference.

2. The index to the external cross-references is tabulated according to the most frequent documents referenced which are not yet on-line.

3. These most frequently referenced documents are the next ones to be put on-line.

4. Steps one to three are repeated during the creation phase. When the frequency of external references (to documents not yet on-line) is small enough, the procedure terminates.

5. As a file is searched, a trace is used so that the frequencies with which documents are actually consulted can be developed. This trace may designate additional documents which should be put on-line. Documents which are on-line, but consulted infrequently, can be removed if needed.

The above algorithm lacks only a stopping rule to make it implementable. We will not specify one here, but we conjecture that it will be optimal to stop whenever the incremental cost of input exceeds the cost of the extra time required to use a hard copy of the document. Such "infinitesimal look-ahead" stopping rules are commonly found in problems which are subject to diminishing returns as the amount of work already done increases.*

CONVERTING TO MACHINE READABLE FORMAT

Almost all of the documents proposed for the data base must be converted to a machine readable form before they can be indexed and stored on-line. It would probably be too expensive to do this if manual methods were used. Based on typical key-stroking speeds and wages, manual input would cost between .4¢ and 1.0¢ per character,** resulting in a cost of about $\$13.2 \times 10^6$ (the actual range is between $\$4.9 \times 10^6$ and $\$21.4 \times 10^6$). These costs, while not extremely large in themselves, are comparable to, or greater than, the cost of the existing hard copy system. For

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*Q. V. Sheldon Ross, *Applied Probability Models with Optimization Applications*, (Holden Day, 1971) ch. 7

**A typical keystroking speed is 2000 characters per hour, with 90-95 per cent accuracy. Using 100 per cent verification to achieve an acceptable error rate gives an effective rate of 1000 characters per hour. Direct labor cost of $4.00 per hour gives a cost of 0.4¢ per character. Overhead and the cost of supervisory personnel could bring this to 1.0¢ per character.

example, a set of ASPR currently costs about $50. Putting ASPR on-line and using it over a time-sharing system might well be more costly.

Optical character reading (OCR) technology offers another way of getting the data into the system. Conversations with firms selling OCR equipment indicate that the job is just at the edge of the state of the art. Currently available systems can recognize up to five different type fonts at 10 or 12 characters per inch density with around 99 per cent accuracy. (That is, the machine correctly recognizes 99 out of 100 characters, and asks for manual intervention for help in identifying the 100th character.) ASPR alone contains five fonts, including a six-point Roman with a density of around 20 characters per inch. Quoted speeds for OCR machines range from 200 to 600 characters per second, assuming that enough human verifiers are assigned to keep up with the one per cent hardware error rate. An OCR system for this application might cost between $250,000 and $500,000. The annual cost for the hardware would be between $88,500 and $177,000.* Labor would cost between $63,000 and $85,000, depending upon how many manual verifiers are needed to keep up with the machine.** Total direct annual costs might, therefore, run between $150,000 and $265,000. This is a cost of about $100 per hour (the actual range is between 75 and 133 $/hr). If the OCR machine can be run at 600 characters per second, this gives a cost of 0.0046¢ per character. If, as seems more likely, the attainable speed is around 200 characters per second, then the cost per character is 0.0139¢. For our file of roughly 1.7×10^9 characters the cost is, therefore, about $236,000. The conversion would require about 2300 hours (a little less than 14 months).

This cost is substantially less than manual input since current OCR technology is now or soon will be up to the task, serious consideration should be given to postponing the creation of the on-line file

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*Assuming a five year depreciation period, zero scrap value, a ten per cent discount rate and ten per cent for maintenance.

**Assuming single shift operation.

until the OCR technology truly is available. By waiting two years, a saving of two orders of magnitude may be possible.

GRAPHICS

A PAS capable of handling the bulk of DoD procurement activity must deal with graphic material. Computer-based graphics in the form of digitally encoded representations of graphic entities present a difficult and expensive problem. It takes a great many bits per image to even approach the performance of paper-and-pencil engineering drawing technology. The information needed to approach the capabilities of half-tone printing of photographic technologies are very large indeed, even with sophisticated image compression techniques.

A number of possible techniques for PAS graphics are surveyed below. None are as easy to use, inexpensive or elegant as we would like:

1. Computer-aided retrieval of microform graphics
2. Video disc technology
3. Facsimile
4. Digital encoding - raster methods
5. Digital encoding - element encoding methods

The first three techniques are 'two-medium' -- images are handled in a separate medium from that used for text.

Computer-Aided Retrieval of Microform Graphics

In this technique text material is stored in the PAS in the usual form of ASCII coded character strings; the associated graphics are stored in photographically reduced form on microfilm or microfiche. Text files contain graphics addressing information that can be used to automatically recover the microform graphics. Each PAS host would have a complete file of current microform graphics; some user installations might maintain duplicates of frequently used graphics. For browsing purposes, a user could command the system to recover a particular image and place it in front of a flying-spot scanner at the host. The video from this scanner would be transmitted to an image-reconstructing CRT for viewing by the user. Image quality would not be good and response would be slow (probably 10's to 100's of seconds). If additional resolution capability is required, the system could be designed to allow user control of a zoom lens on the flying-spot scanner to permit enlargement of parts of the image. If the user wanted hard copy he could command the host system to create it and mail it to him. Alternatively (and more expensively), some user installations could be equipped with Gould, Varian or Versatec matrix printers which produce hard copy on-line.

This technique has the drawback of requiring dedication of the graphics viewing flying-spot scanner to one user at a time. For a PAS host with one image scanner and supporting 100 simultaneous users this implies that the ratio of user graphics viewing to text processing time is 0.01 or less. Larger ratios require more scanners.

Video Disc Technology

A number of manufacturers are preparing to produce and market systems for recording and playing TV images from plastic discs about the size of LP records. The technology looks like it will support approximately 10^{10} bits per disc; enough for 6,600 black and white images with 6 bits of gray scale or 36,000 images with no gray scale (275,625 picture elements per image). Some manufacturers are considering the use of digital image encoding (PCM), making computer control of image searching easier. Thus, video discs could be used for image storage instead of the microforms discussed above. It is probable that video disc playback equipment will be considerably less expensive than flying-spot scanners. Single disc playback systems are estimated to retail for $400-$500 in 1976, but data inputting will still require mechanical paper handling.

Facsimile

Facsimile operation is similar to the microform technique discussed above, except that no on-line browsing capability could be provided. To use this technology, each PAS host would be equipped with system-controlled facsimile transmitters; each user installation desiring graphics would have a facsimile receiver. Text files contain a brief description of each graphic image as well as addressing information for it. If the user wants to see a particular image he requests it from the system. Such requests are queued; the graphic images are pulled and transmitted by facsimile during the second and third shift of the day of the request. At one minute per image the host could handle 960 images per transmitter during these two shifts. This technique offers next-day availability and resolution adequate for newspaper quality photographs.

Digital Encoding

Digitally encoded graphics allow image files to be merged with and handled in the same way as text files, a significant advantage over the first three techniques. The techniques discussed below can handle images with no color or gray scale reasonably well. They can also be used for images with color and/or gray scale, but the number of bits required rises considerably. It is our present opinion that digital encoding should only be used for images without these complexities.

Raster Methods. Images can be mapped into serial binary vectors by scanning TV fashion from left to right and from top to bottom, recording a 1 for each occupied picture element and an 0 for each empty one. This results in sparse vectors since most images are largely empty space. A fairly dense raster is required for reasonable resolution: 512 x 512 to approximate home TV resolution. A flying-spot scanner can be built which maps from images to vectors automatically.

The vectors produced by the flying-spot scanner can be compressed in a number of ways to remove redundancy. One possible technique is as follows:

1. Define coordinates for the image space and record its four corners.

2. Use the Warnock shrinking window method to define minimal rectangular areas containing drawing elements of interest; define the raster type (64x64, 128x128, 256x256, or etc.) needed for good resolution.

3. Record the location and raster type of each such area and the binary vector defining the image in the area.

4. If the area contains only a line of characters record the location of the area, a dummy raster type indicating characters, a scale factor and the characters in ASCII.

Element Encoding Methods. Image elements can be described more compactly by redundancy reducing encoding which seeks line segments. A possible application of this technique is as follows:

1. Use the flying-spot scanner to convert the images into machine readable form by;

a. the raster scan technique discussed above, or

b. a curve-following technique in which the flying-spot scanner beam is servod to trace all the lines in the image and record pairs of coordinates for the strings of points that comprise each image element.

2. Use curve fitting techniques on data derived from 1. to generate analytic geometric, polynomial or B spline representations of each image element.

3. Use OCR techniques to identify lines of characters; encode them in ASCII.

Both methods described above are probably feasible, but suffer from formidable disadvantages:

. A significant amount of computation is required to convert images to compressed digital form.

. The user CRT terminal must apply an equivalent inverse computation to convert from digital to image form.

. Some kinds of images will require inordinately large amounts of computation and/or storage. Some fraction of the images will require manual intervention in the encoding process to resolve ambiguities.

In summary, none of the proposed graphics techniques seems capable of handling the number of documents or the volume of requests which the PAS files would generate. Some are limited by the special equipment which they require at the host. This prevents them from lowering costs by multiplexing user requests. Others require special terminals at user locations or cannot provide browsing or high picture quality. Both features would be required by a PAS for use as a reference system by contractors.

SUMMARY AND CONCLUSIONS

This paper began by estimating the sizes of the large static files which would be used in the PAS. These files would form the core of a system for on-line retrieval of procurement-related documents. Based on measurements of document thickness, we estimated a file size of 1.7 ($\pm$ 0.4) x 10^9 characters of raw text. If service and command level documents which are redundant were compressed out of the file, its size would be about 10^9 characters.

On-line memories already exist which can store files of this size and their associated indexes. Therefore, this paper examined the two other bottlenecks which exist in creating this information system. We found that evolution in OCR technology may make it possible to use printed text as the source material. The estimated cost of OCR conversion of procurement documents to machine readable form was about 0.01¢ per character, compared with a keystroking cost of about 0.7¢ per character.

The other bottleneck concerned the input, storage and retrieval of graphics. Here we found that no currently available technique offered adequate capabilities at a reasonable cost. A PAS file system limited to current technology would not be satisfactory from a user's standpoint or cost-effective from DoD's standpoint.

We are thus forced to conclude that until a significant advance occurs in graphics technology the large file system originally proposed in this paper will not be feasible. However, information applications which require large files of text (but few graphics) are feasible. For instance, a file composed of most high-level procurement documents would not be difficult or expensive to create and use. These documents are already available in a form suitable for OCR scanning and contain only simple graphics such as boxes around parts of forms. Some files are already available on-line, such as ASPR and the U.S. Code. An existing information retrieval system such as the SPIRES system could be used to process and index the input text and retrieve portions under on-line control. Appendix B discusses this proposal in more detail.

However, we have considerable confidence that the graphics bottleneck will be overcome in the next decade. Many approaches are currently being pursued vigorously, and it may be only a matter of time before one of these (or one not yet thought of) results in the sort of advance required by this and many other applications. This advance will release the capabilities latent in current technologies to provide a complete on-line information system for Defense procurement.

APPENDIX D

HARDWARE/SOFTWARE PRIVACY AND SECURITY CONSIDERATIONS

by

David C. Caulkins

INTRODUCTION

The Procurement Automation System (PAS) must be able to restrict access to certain data if it is to be fully useful. These data will be of two types: data bearing a government security classification marking; and proprietary information supplied by private organizations. Providing the needed security is not easy. Two surveys of the subject, one recent, Hoffman,* and one old, Kerchkhoff,** describe some of the difficulties encountered in the creation of a system with the high level of security desired. This appendix describes a proposed approach to help achieve a level of privacy and security protection adequate for the needs of the PAS. Much development will be needed to carry the conceptual schemes presented into practice and the cost of providing this privacy and security will be substantial.

In this appendix the writer suggests (among other things) what he believes to be a novel cryptographic technique. However, not having access to the highly classified literature of cryptographics may mean that what is proposed here may be old hat. Nevertheless, these or similar techniques can form a cost-effective part of the PAS privacy and security system raising the price to an intervenor sufficiently high so that he would tend to obtain the same data elsewhere, more cheaply.

The privacy and security system the writer proposes has six elements:

Cryptographic Techniques. Special hardware-based cryptographic techniques are used to protect PAS communication links and to encrypt sensitive files.

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*L. J. Hoffman, *Security and Privacy in Computer Systems*, New York: Melville Publishing Company, 1973.

**A. Kerchkhoff, *La Cryptographie Militaire*, Paris: Librairie Militaire de L. Baudoin & Cie., 1883.

System Software Design. All system software is designed and built with security requirements in mind. In particular, all user access to system resources is via system software explicitly designed to prevent unauthorized use of resources. No machine code other than that from the authorized system programming staff is ever run on the system.

User Authentication. Depending on the security level of the material to be accessed, a series of both machine-originated queries and face-to-face human identification techniques are used.

Compartmentalization. System elements crucial to preservation of security are kept in secure areas and provided with adequate conventional physical security in place and in transit. Such elements include cryptographic keybases, programs controlling cryptographic operations (including both machine and human-readable documentation as well as the special terminals permitting access to systems programs) and the machines on which the PAS runs. System elements not crucial to preservation of security (the design of the encrypt/decrypt devices, user terminals, etc.) are not routinely subjected to security procedures.

Continuous Proof Testing. A PAS proof test group should be a permanent entity. This group should consist of highly skilled and motivated people whose sole charter is to penetrate the system.

Audit Trails. Audit records will be kept for almost all PAS files showing for each access:

- the identity of the user
- the duration of access
- the time and date of access
- the actions taken (read/add/change/delete/copy)

These audit records will have management as well as security uses.

Each of these elements will be discussed below.

CRYPTOGRAPHIC TECHNIQUES

This section discusses some criteria for secrecy systems, then goes on to describe what I believe to be a novel cryptographic device. It is my belief that this device is inexpensive and powerful enough so that cryptography becomes a low-cost service that can be widely applied. In particular it should be possible to provide conventional services (communications encryption and file encryption by the system) and also novel services (file encryption by the user using a keybase unique to him and available to no other human;

encrypted programs which are resident in the system and are only decrypted by hardware as they are executed). The key space is quite large (10^{15} combinations) and could be expanded by many orders of magnitude at small cost.

Both Shannon* and Kerchkhoff** present lists of criteria for evaluating proposed secrecy systems. The two lists are fairly similar (even though Kerchkhoff preceded Shanon by 66 years). These criteria relevant to our discussion include:

1. The system should require a large amount of effort and/or intercepted material on the part of the cryptanalyst*** to penetrate the system.

2. The key must be transmitted by non-interceptible means from transmitting to receiving points; it should therefore be as small as possible.

3. Enciphering and deciphering should be as simple as possible to avoid error (if done manually) or by large and expensive machines (if done automatically).

4. Propagation of errors from enciphering or communication medium sources should be minimized.

5. Expansion of the message as a result of the enciphering process is undesirable.

6. Knowledge by the enemy of the details of the system (excluding, of course, the keys) should not adversely affect the security of its use.

Criteria 1 - 5 are from Shannon; 6 is unique to Kerchkhoff.

I believe technological advances have substantially altered Criteria 2, 3 and 4.

For the system we propose, Criterion 2 applies to key*bases* rather than the keys themselves. As shown below keybase requirements for the PAS system should be less than 10^7 bits per day. Generation and distribution of this volume of keybases appears quite feasible. No keybase distribution system can be non-

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*C. E. Shannon, "Communication Theory of Secrecy Systems," *Bell System Technical Journal*, Vol. 28, October, 1949.

**Op. cit.

***A brief glossary of cryptographic terms is presented at the end of this paper.

interceptible in an absolute sense. In this respect the system proposed here is no more vulnerable than any other secure transmission system; if the cryptanalyst has access to the same information as the message receiver he can also decrypt the message. We believe our system has features which can make it resistant to cryptanalysis even if some keybases are compromised. To achieve this resistance we recommend that many more keybases should be generated and distributed than will be used. Mere possession of an intercepted keybase will then not be very useful to the cryptanalyst, because there is a high probability that it will not be used. Even if it is used, the cryptanalyst must know when and where it is to be employed in order to decrypt the message encrypted with it. Possession of such a keybase gives no information about other keybases or keys.

With respect to Criterion 3 the machines necessary for automatic enciphering and deciphering can now be small and cheap. In consequence complexity becomes a virtue.

With respect to Criterion 4 we believe that cryptography and error minimization should be dealt with by two separate mechanisms, because their requirements are different and in some cases conflicting. From a cryptographic point of view, it is desirable to use special coding such as Huffman to "squeeze out" redundancy in a message and make cryptanalysis more difficult. This causes random errors appearing within a message to garble more of the message than would be the case with normally redundant coding. Such garbling is probably desirable in that it lowers the probability of an erroneous but seemingly correct message.

Error correction can be dealt with in the same fashion as the ARPANET. Encrypted messages are formed into packets and error detecting redundancy is added in the form of a field of error detecting code bits. With this technique, used in conjunction with a retransmission-on-error strategy, the error rate can be fixed at any arbitrary level and is independent of the degree of redundancy within the body of the message.

We assume that the PAS hardware and software will be similar to the one discussed in Cabledata Report R-148* and in this report. From the security point of view the PAS will have four significant sections:

1. The host computer centers.
2. The network message processing machines.
3. The terminals available to users for interaction with PAS.
4. The communication facilities linking 1, 2 and 3.

Our design assumes that the first two sections are in secure locations where necessary security restrictions can be imposed. We assume that the last two sections are insecure; i.e., sophisticated, highly motivated and well equipped groups with the desire to penetrate PAS security have continuous access to them. We propose a two-level system as shown in Figure D-1. End-to-end encryption is applied to data exchanged between terminal and host (or host and host); in addition, data sent from one network node to another is encrypted a second time. This second level of encryption serves to conceal packet header information (source, destination, etc.) as well as complicating the task of the cryptanalyst using wire-tapping to gain access to a network link.

Encrypt/Decrypt Hardware

The heart of the system is a general purpose encrypt/decrypt device (EDD) shown in Figure D-2. It mechanizes a type of Vernam cipher. The thrust of the EDD design is to create a key generator whose operation is exceedingly difficult to reconstruct in the absence of knowledge of the keybase used. This is true even though the cryptanalyst is familiar with the details (or even in possession) of an EDD. The output of this generator is used as an approximation to the "one-time tape" of the pure Vernam cipher.

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*Cabledata Associates, *ARPANET MANAGEMENT STUDIES: New Application Areas*, report R-148, Palo Alto, Calif.: Cabledata Associates, May 1974.

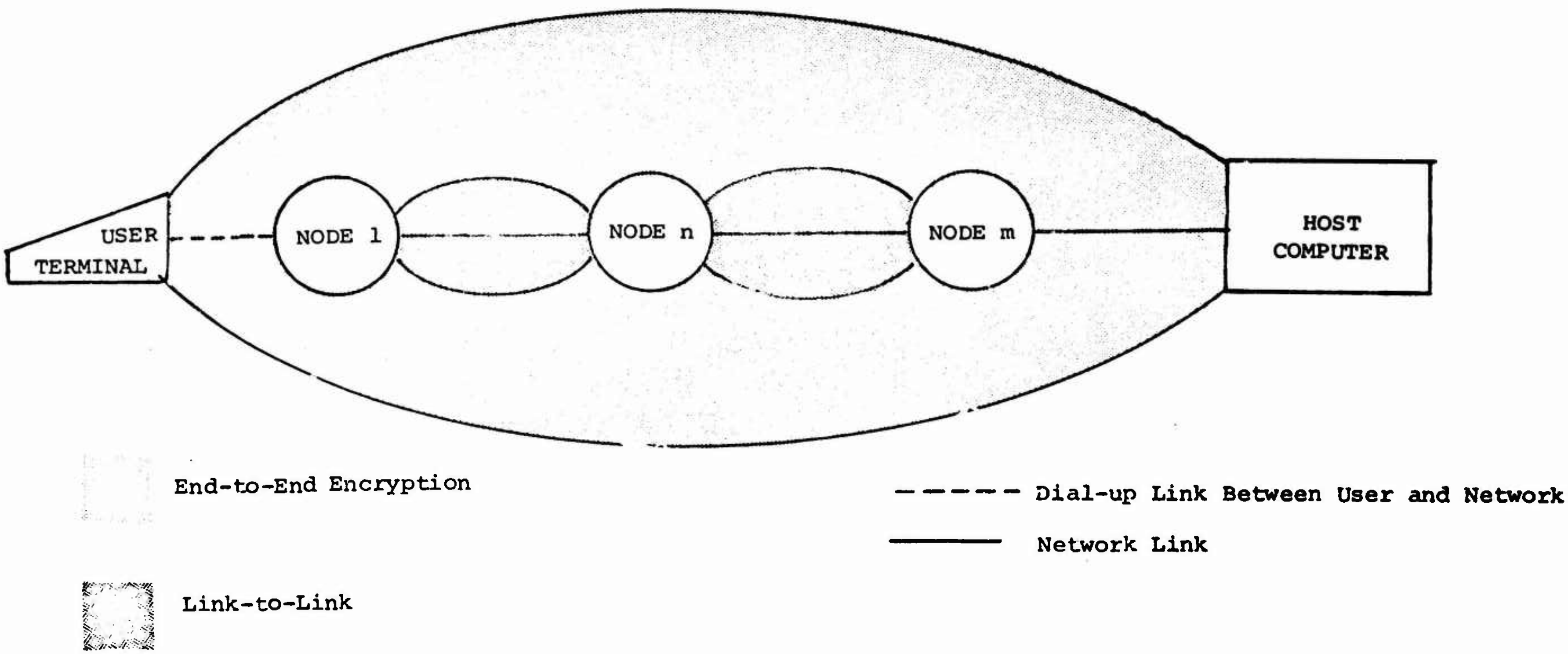

Figure D-1. Two level encryption

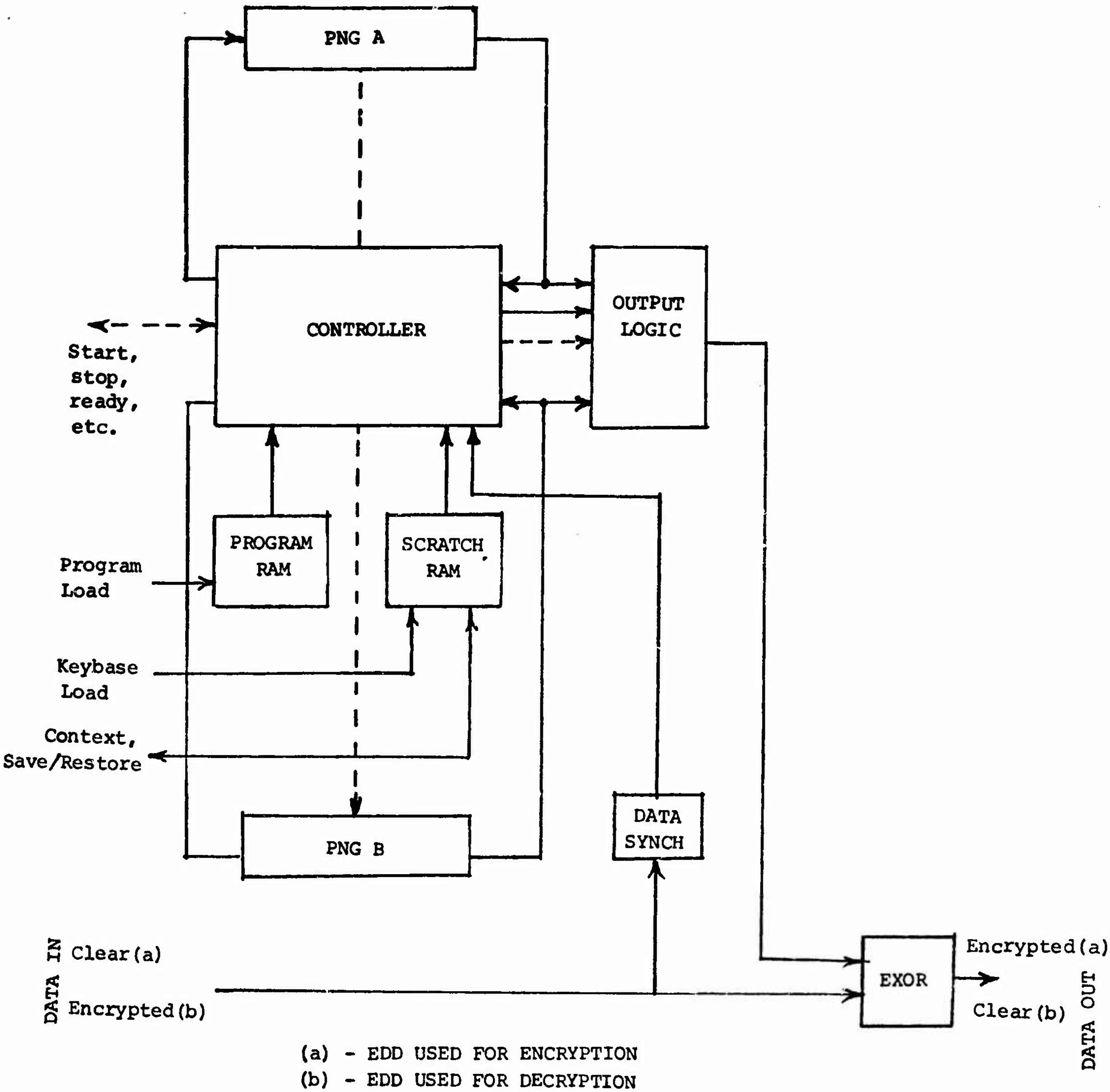

Figure D-2. Encrypt/Decrypt Device (EDD).

The EDD of Figure D-2 accepts a keybase of modest length -- a binary string about 50 bits long. It uses this keybase to carry on a binary key generation process with four important characteristics:

1. The generated key approximates a random string.

2. Two EDD's supplied with the same keybase will produce identical and unique keys.

3. The transformation relating the keybase to the key is highly complex; so much so that in practice the effort required to recreate the key without access to the keybase is prohibitively large. The transformation is similar to the non-invertable function H discussed in Evans, Kantrowitz and Weiss.*

4. The transformation is a good "mixing function" (in the sense of Shannon) in that all the bits of the keybase participate intimately and approximately equally in the production of the key.

The EDD has three major parts:

1. A programmable controller capable of executing a program stored in the program RAM.

2. Two pseudo-random number generators, PNG A and PNG B. These are feedback shift registers whose feedback paths register contents and operations are dynamically determined by the controller.

3. The output logic. The controller dynamically determines whether the binary key will be the output from PNG A, PNG B, the EXOR of PNG A and B, the EXOR of the register and PNG A or B, etc.

Operation

The EDD would operate as follows:

A keybase is loaded into the scratch RAM and the START line to the controller is raised. The controller maps the keybase into a series of operations that generate initializing vectors for PNG A, B, and the output logic register; configures the feedback paths of PNG A and B; and configures the output logic to provide a particular combination of PNG A, PNG B and/or the output logic register

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*A. Evans, Jr., W. Kantrowitz and E. Weiss, "A User Authentication Scheme Not Involving Secrecy In the Computer," *Communications of the ACM*, vol. 17, no. 8, August, 1974.

as the binary key. The controller then raises the READY control line. At any time after this, data bits may be sent to the EDD; each one will be EXOR'd with a bit of the binary key. After each such data bit, the controller tests to see if the next keybase segment matches the output of PNG A (or PNG B; determined by previous controller activity). If a match is detected, the controller uses the keybase and/or a PNG output to execute one or more configuration change operations which modify the key generation algorithm in a complex way. The keybase segment used in the matching operation is itself subject to change, but is kept within a range that insures a match will occur every 8 to 1024 data bits, with a mean of around 50. Table D-1 lists some possible configuration change operations, several inspired by Evans, Kantrowitz and Weiss.

A possible algorithm (there appear to be a large number of reasonable ones) for controller operation sequence is as follows:

1. Map the next segment(s) of the keybase into one of the operations of Table D-1. If this operation is one of Groups A, B or C and requires an auxiliary operation, map the next segment of the keybase into the required operation subset.

2. Repeat 1 until one of the operations of Groups C, D or E is carried out.

3. Wait until the next keybase segment match; then go to 1.

Discussion

We see several possible problems in the operation of the EDD. The controller could get into an "infinite loop" state in which it repeats the same small subset of configuration change operations, resulting in a repetitive key. While this is an unlikely situation one possible countermeasure is to have the controller generate a count of the number of times each of the operations of Table D-1 is used; this count would be an input parameter to the operation selection process, and operations would be selected so as to equalize all counts.

Table D-1

CONTROLLER CONFIGURATION CHANGE OPERATIONS

A. Operand source selection:
    PNG A
    PNG B
    keybase (next segment)

B. Data modification:
    shift
    rotate
    exchange bits/bytes
    add bytes
    table lookup

C. Operand destination selection:
    PNG A content register
    PNG A configuration register
    PNG B content register
    PNG B configuration register
    output logic register

D. Output logic control:
    enable key = (PNG A) EXOR (PNG B)
    enable key = PNG A
    enable key = PNG B
    enable key = (output logic register) EXOR (PNG A) Note 1
    enable key = (output logic register) EXOR (PNG B) Note 1

E. Keybase segment control:
    set keybase segment size to n
    match keybase segment with PNG A
    match keybase segment with PNG B

Note 1 - default to one of the first three output logic control operations if the output logic register is exhausted.

Also as indicated in Meyer* and in Golomb,** certain configurations of feedback shift registers generate sequences with poor random properties and/or are vulnerable to cryptanalytic attack. The continuous and essentially random changes in EDD key generation should make the period occupied by a poor quality sequence small, but, even so, it is probably wise to require that the EDD restrict its configurations of PNG A and B to those with good properties. Desirable configurations are described in Golomb, and in Hurd.*** The controller should avoid using PNG A or B as the sole unmodified source of the key for long periods.

Third, the theoretical basis for the existence of the four keybase characteristics described above is not as firmly established as we would like. It should not be difficult to do a computer simulation of an EDD; we recommend that such a simulation be done.

The EDD has a number of interesting advantages:

1. It offers "key change" type protection against cryptanalysis on two levels below that of keybase change.

   a. The controller operation sequence algorithm can be changed; and

   b. the configuration change operations of Table D-1 can be altered or augmented.

   Either or both of these changes can be easily carried out by reloading the program RAM.

2. When mechanized with MOS for use with terminals it should be small, inexpensive (possibly $1,000 to $5,000 in modest production runs) and capable of operation at or below 10,000 BPS.

3. When used in conjunction with minimum-redundancy encoding of the Huffman type, the EDD closely approximates an ideal secrecy system as defined in Shannon, Section 17.

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*C. H. Meyer, "Design Considerations for Cryptography," *National Computer Conference Proceedings*, vol. 42 (AFIPS Press), 1973.

**S. W. Golomb, *Shift Register Sequences*, Holden-day, Inc. , 1967.

***W. J. Hurd, "Efficient Generation of Statistically Good Psuedonoise By Linearly Interconnected Shift Registers," *IEEE Transactions On Computers*, vol. C-23, no. 2, February, 1974.

An Alternative to the EDD

Bolt, Beranek and Newman, Inc. is building a device called the Private Line Interface (PLI), intended to perform encryption/decryption between hosts handling classified data via a non-secure network.* It is our understanding that the PLI will contain a secrecy subsystem under cognizant control of the security agency. The PLI key generator will operate at 30 KBPS in initial versions; the design should support 100 KBPS without difficulty. The PLI appears suitable for end-to-end encryption in host-host communication; but it is probably too large and expensive for host-terminal or TIP-terminal use.

SYSTEM SOFTWARE DESIGN

The design of the PAS software to accommodate an adequate privacy and security operation is a major undertaking. Even to outline what the design specification should be involves substantial effort. In this appendix we present a series of approaches, which we hope to refine as a result of our work on the balance of this contract.

The Formulary Technique

We believe that the Formulary Technique of Hoffman (Section IV),** is promising. Some of the salient features of the technique are as follows: access control and other privacy and security matters would be handled by sets of procedures called formularies. Since these are programs rather than just flags, tables or arrays, control is flexible, dynamic and adaptable to changing PAS requirements. Degree and type data access decisions are made at access rather than at creation time. A series of "talk" programs would be provided for communication with users. These are application-oriented storage and retrieval procedures that mediate between the operating system and the user. They typically deal with three parameters and none, some, or all may be supplied by the user:

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*D. Malpass, (private communication to Cabledata Associates), August, 1974.

**Hoffman, Op. cit.

1. A datum description.
2. The operation to be performed on that datum.
3. User identification, terminal identification and/or other verification data.

Talk programs can be used to control the user's access to PAS even to the extent of concealment of the existence of segments of the system or database. The Scramble and Unscramble procedures discussed in Hoffman, Section IV, would be carried out using the cryptographic techniques discussed elsewhere in this report.

We also believe that the Security Kernel concept* has application to PAS. The PAS hardware discussed in Appendix I of Cabledata R-148** could be structured so that the security kernel would be resident in a read-only memory from which execution only by the diagnostic processor would be permitted. Properly designed, a system of this kind could preserve the integrity of the security kernel even from a system programmer able to dump and examine all other parts of the system.

User Code Limitation

We feel that a large class of privacy and security problems discussed in Hoffman can be eliminated by imposing the restriction that no machine code is ever run on PAS except that originated by the system programming staff. This restriction is not as confining as it might first appear. Users could be allowed to 'compile' higher level language source code or even 'assemble' machine code. Actual execution would be via a PAS interpreter carefully designed to prevent (and use the audit trails to record) any privacy or security violations. The system pays for this protection in decreased efficiency and the cost of building the necessary interpreters.

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* G. J. Popek, "Protection Structures," *Computer*, vol. 7, no. 6, June 1974.

** Op. cit.

Cryptography

The cryptography techniques discussed in this report must be supported by appropriate software. In particular the PAS host must request the user desiring cryptographic access to load a particular keybase into his EDD; the host must load its own local EDD with the same keybase and control the resulting exchange of encrypted data. One or more PAS hosts must generate keybases and supply them in a timely fashion to the off-line secure keybase distribution agency.

Many files forming part of host databases could be encrypted using keybases generated for this internal purpose only. Hosts will need to keep files of encrypted file keybases; these in turn will also be encrypted. System integrity requires absolute security in the generation, distribution and use of keybases. The software handling these functions must be designed accordingly.

An estimate of the quantity of keybases required can be made as follows: Assume a PAS with 12 hosts, each supporting 100 active users. Assume further that each user spends 2 hours a day on the system and that keybases are valid for 10 minutes (all conservative assumptions tending to maximize the number of keybases required).

12 x 100 x 50 x 12 = 720,000 bits of keybase required per day.

720,000 x 10 = 7.2×10^6 bits of keybase to be generated and distributed to permit 90% unused keybases. This would fit easily on 3 floppy disks, but would obviously be divided among as many floppies as there are PAS user installations.

Mapping

The PAS hardware discussed in Appendix I of Cabledata R-148 * contains a memory map unit as part of the main memory. This device translates virtual into absolute memory addresses for use by the paging and memory management sections of the PAS operating system. We believe that in addition to these functions the mapper can be used for certain special privacy and security purposes. In particular it should be possible temporarily to dedicate a main memory field to one highly classified job being serviced by a single

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*Op. cit.

carefully restricted process. The PAS operating system diagnostic processor would take special precautions to assure that no other mappings into the dedicated memory field could occur. A similar scheme is implemented in Multics; the protected domains are called protection rings.*

This is an idea in process of formulation -- we only mention it here and hope to pursue and refine it further.

AUTHENTICATION

We do not have an optimal solution to the authentication problem -- insuring that a person requesting system access from a remote terminal is who he says he is. We suggest the following scheme, which we view as adequate but not elegant.

Each installation having PAS terminals used to access sensitive parts of the PAS database would have a PAS security officer. This individual would be responsible for vouching for the identity, clearance level and need-to-know of people from his installation who applied to him for access to sensitive PAS material. He would also be in charge of receiving, storing and disbursing PAS cryptographic material (keybases, EDD programs, etc.). At appropriate intervals he would receive (by a secure route probably other than the PAS network) groups of keybases in machine readable form, probably on floppy disks.

When a user wished to access sensitive PAS data, he would conduct a dialog with a query program section of the PAS security software. This would request some prearranged authentication information of the "what's your wife's maiden name" variety; on a random sampling basis much more detailed information would be required. The query program would then instruct the user to go to the security officer and sign out a particular keybase for use during a specific short period -- probably between 10's and 100's of minutes. The

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* J. H. Saltzer and M. D. Schroeder, *A Hardware Architecture For Implementing Protection Rings*, Communications of the ACM, vol. 15, no. 3, March 1972.

user would go to the security officer, identify himself and sign out the PAS indicated keybase (given to him in machine readable form), return to his terminal and load the keybase into the EDD on his terminal. He would then notify the PAS and all further communication between the PAS and the terminal would be encrypted using this keybase.

The security officer would be notified by the PAS of all keybase requests; any request without the appearance of the user to obtain the keybase would be grounds for investigation. Similarly, the security officer would be alerted by the PAS in the event of any invalid or suspicious user responses during PAS originated authentication queries. All users (suspicious or otherwise) would be treated by the software executive system as if they had successfully completed the authentication queries and be sent to the security officer.

COMPARTMENTALIZATION

This involves dividing the PAS into groups (of devices and/or data) and providing each with an appropriate degree and level-of-effort of security. Table D-2, below, presents one possible scheme.

Table D-2

PAS SECURITY COMPARTMENTS

Security Level			
High	Medium	Low	None
Security Kernel End-to-end keybases Host hardware System programming terminals	IMP,TIP keybases System software IMP,TIP hardware	IMP,TIP software	User terminals EDDs Communication links

CONTINUOUS PROOF TESTING

If one thing is clear from the history of secrecy systems it is that even modest assumptions about the ability of theoretically powerful systems to withstand penetration is dangerous. We therefore recommend that an essential part of the PAS privacy and security system be a group of highly skilled and motivated people whose sole charter is to penetrate the system. Some members of this group should be periodically exchanged with members of the system programming staff so that both those trying to build and those trying to break the system should have detailed knowledge of what it's like to be on the other side. Some proof testing group members should also be recruited from outside in order to prevent the testing process from becoming routine and/or incestuous, and thus ineffectual. A special class of candidates for group membership would be young, clever and naturally mischievous or rebellious people -- MIT undergraduates, phone phreaks, etc.

AUDIT TRAILS

The PAS should be provided with software that will maintain audit trails on accesses for almost all files. The main use of these will be managerial, but the security system will be able to recreate file access histories from them. These can be used to create normal usage profiles for files, installations and even particular individuals. Departures from these profiles can be used to detect unusual and therefore suspicious access to sensitive materials.

To achieve adequate usefulness, these audit trail files will have to be quite large. In order to keep them from unduly burdening the system they will be transferred as rapidly as possible to an off-line archival medium such as magnetic tape.

CRYPTOGRAPHIC TERM GLOSSARY

This glossary defines cryptographic terms as they are used in this paper. No universality is implied or intended.

Cipher - a particular procedure for encrypting and decrypting messages.

Clear - a message and/or bit stream that has not been encrypted or has gone through the decryption process.

Cryptanalyst - a person or group attempting to recover clear messages from encrypted ones, generally with hostile intent.

Key - data combined with clear message data to produce encrypted data; or data combined with encrypted data to produce clear message data.

Keybase - a short (10-100 bit) binary sequence used in conjunction with a key generator to produce a unique key.

Key Generator - a device that will generate a unique key from each of a large population of keybases.

Vernam Cipher - the only cipher known to be unbreakable. A stream of random bits as long as the stream of message bits is used as the unique key for a single message. The key is added (modulo 2) bit-by-bit with the message to either encrypt or decrypt.

APPENDIX E

PRESENT STATUS OF PROCUREMENT
AUTOMATION IN DoD

by

Marc U. Porat

SUMMARY

The Procurement Automation System is an advanced management concept, requiring a number of critical modules. A field survey of *already existing* systems and systems in design was conducted in Summer 1974. In the aggregate, most of the modules or capabilities necessary to implement a PAS system appear to be in place or in development. These are: logistic and systems procurement; contract administration; information utilities; and OSD conceptual commitment (through MILSCAP).

The ten systems we surveyed are developing in a semi-autonomous fashion; most are "mature" and fully operational. Several more will be implemented in 1975. Among them they maintain an enormous database, dozens of computers, and a large support staff. They serve hundreds of user sites, distributed world-wide, and monitor procurement transactions worth billions of dollars. The procurement automation "community" has accumulated 10-15 years of direct experience with relevant management and computer techniques.

Among the ten systems we found that all the necessary conceptual capabilities for PAS existed with four apparent exceptions:

1. Absence of comprehensive external standards.

2. Absence of low-cost, widespread, effective computer communications capability.

3. Absence of early system thinking to permit ready conversion to widespread computer resource sharing.

4. Absence and overall system architecture and design.

ANALYSIS

A Typology of Systems

Various branches of DoD have shown awareness of procurement automation needs since the early 1960's, when EDP systems were developed on a relatively ad-hoc basis to solve spot needs. As computing power increased and the availability of computing talent and acceptance became more general, the procurement EDP activities grew in scope. The growth, a bottom-up phenomenon, drew some early distinctions which appear to have survived until today.

Branch-oriented or DoD-wide? Until the MILSCAP directive of 10 Jan 1968, the various procurement and contracting MIS were developed with minimal concern for DoD-wide communication. The merit of such a practice should not go unnoted, namely, that the invention and implementation of new systems were allowed to proliferate in a manner that encouraged innovation. An early "freeze" on ideas would have restricted the variety of forms created, and good ideas would have been lost. By the mid-sixties DoD realized that there had developed a "glut" on the idea market, and that some forms would necessarily fail in competition. Again, this was a healthy stage -- less successful systems lost their claim on scarce computing and managerial resources, while the more successful ones were reinforced. We are now at the third stage of the process with each branch developing healthy, effective systems. The selection decisions have moved up from the branch level to the OSD level. The next evolutionary phase will see branch-particular systems becoming generalized to DoD-wide application.

Logistic or Systems Commands? For thoroughly sound organizational reasons, the early efforts in procurement automation drew a sharp distinction between logistic support and major weapons system acquisition. The nature of the transactions was qualitatively different, and implied different approaches. Whereas the former was highly routinized, the latter was typically "hand massaged", unique, and not easily reduced to standard operating procedure. Therefore the logistic and systems commands developed separate MIS -- a situation still true today.

Internal or External Standards? The key to successful coordination is the development and implementation of good standards. The system boundary, in fact, is defined by its nonconformity to the adjoining system's "language." This is true at every level of a hierarchy, whether at the office, lab, base, command, or branch level. Each branch realized the problem as two-fold.

First, one must develop "internal" standards so that systems within the hierarchy can talk to each other. This has generally been conceived as intra-branch standardization (with the exception of DSA, which saw it as an intra-DoD problem).

Second, one must develop "external" standards to talk to parallel hierarchies. This has generally been conceived as inter-branch and branch-contractor standardization (except DSA, which understood it only as DoD contractor standardization). The distinction remains with us today, some systems which are internal only, and some which are both internal and external.

A TYPOLOGY

The Procurement Automation System (discussed elsewhere in this report) addresses the shaded cube in Fig. E-1. That is, the PAS can be seen as (a) DoD-wide (b) systems command plus logistic support procurement and contracting system, which (c) has both internal and external interface capabilities.

Most of the key elements necessary for the shaded cube *already exist*. A few key elements are missing. The next section will offer a brief analysis of what exists and what capabilities need to be developed. (See Tables E-1 and E-2)

What Exists?

The logistic support activities have enjoyed the highest degree of automation. This is true at the base level (e.g. CIAPS), as well as at the branch level (e.g. ALS, ALPHA). In addition, DSA's support mission (e.g. SAMMS) has fostered a broadening of interface standards both between branches and across to contractors. The activity is well-known, and both the organizational structures and software appear to be mature; that is, the automated procure-

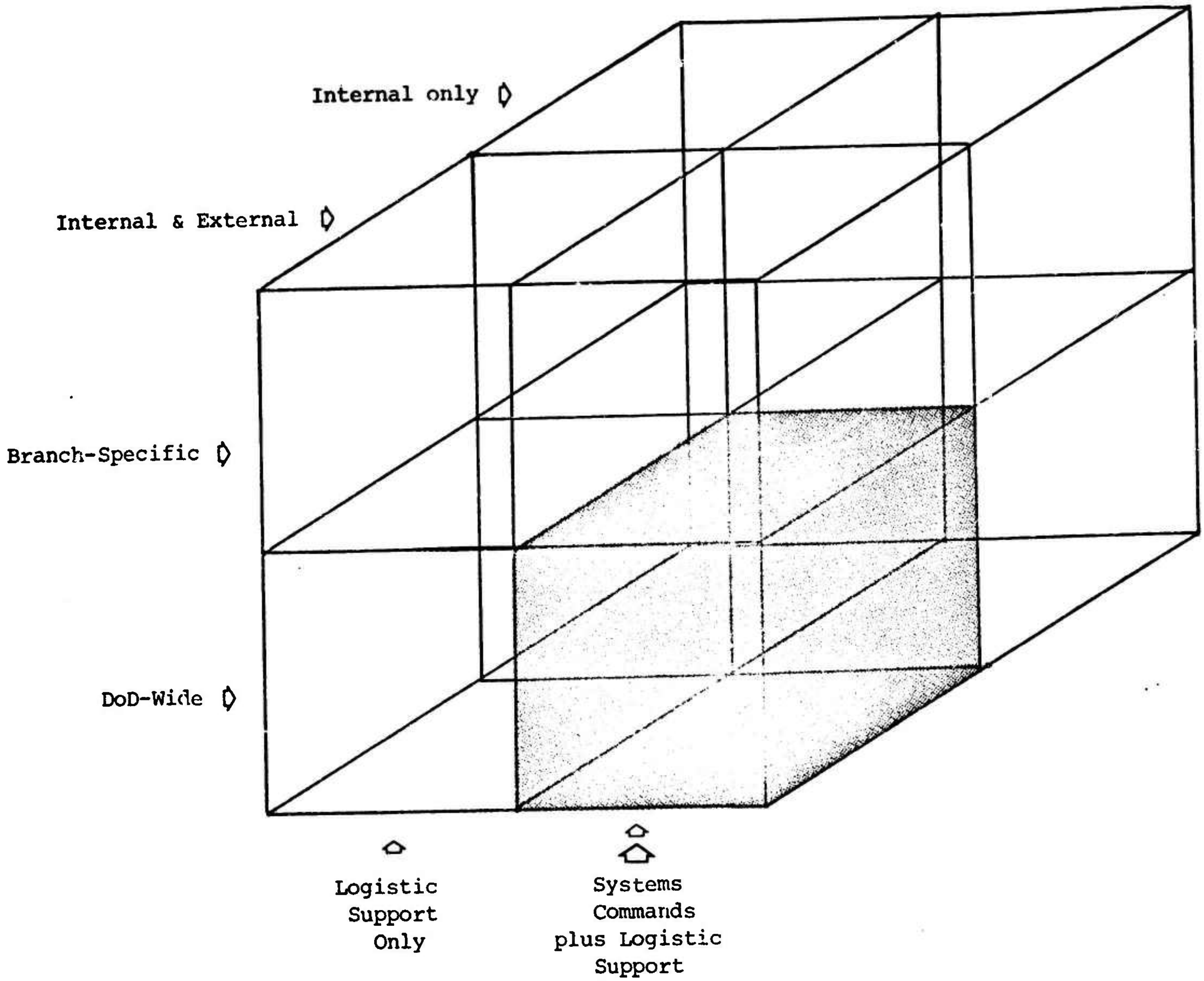

Figure E-1. A typology of procurement systems

Table E-1

PROCUREMENT SYSTEMS SURVEY

	DSA/DCAS	AF	Navy	Army
SYSTEMS	none	AMIS	Individual Commands	SAFEGUARD (SMIS)
LOGISTIC	MOCAS SAMMS etc.	ALS CIAPS	Individual Commands	ALPHA CCSS
DoD-wide	ASPR Committee MILSCAP Directive			
Info Utility	Avionics Central LITE			

Table E-2

ELEMENTS OF A PROCUREMENT AUTOMATION SYSTEM

	Here	In Design	Missing
Army Systems Procurement MIS		x	
Navy Systems Procurement MIS		x	
AF Systems Procurement MIS		x	
Army Logistic Procurement MIS	x		
Navy Logistic Procurement MIS	x		
AF Logistic Procurement MIS	x		
DSA Logistic Procurement MIS	x		
Contract administration	x		
Information utilities (ASPRs etc)	x		
Text editor	x		
Information storage & retrieval	x		
Graphic capability		x	
Internal (within branch) interface		x	
External (to contractors) interface			x
DoD-wide interface		x	
Computers	x		
Memory	x		
Terminals	x		
Communications network			x
Computer resource sharing			x
Overall system concept (MILSCAP)		x	
Overall system architecture			x

ment functions are carrying an increasingly heavier operational load. Also, the contract administration facet of logistic procurement (e.g. MOCAS) enjoys an important operational role.

These systems are not in themselves or in concept completely handling the job. However, the most important parts have been accomplished: (a) the *thinking* has had a chance to be tempered by experience, (b) the *design* facilities, the programming shops (e.g. the Design Center at Gunnard AFB) are in full swing with a seasoned staff (c) the *implementation* and retrofit headaches have been confronted and tamed, and (d) the *evaluation* and *re-design* procedures are in evidence. In organizational manpower, and technological aspects, the capability exists to expand and grow. If a particular problem emerges, the necessary resources are generally available, albeit unmobilized

On the weapons procurement, the picture is not as clear. As was previously mentioned, the large systems procurement process is qualitatively different from logistic procurement. Whereas the latter is routinized, the former is unique. In fact, the operational distinction between logistic and system (ALS and AMIS) hinges on the "uniqueness" of the procured item. When, for example, an airplane is in the R and D and prototype stage, it is in the system command. When the aircraft moves to the production phase -- with part numbers, off the shelf items, and "frozen" or contracted procedures for delivery, repair etc. -- the product is deemed sufficiently "routine" to enter the logistic command.

DoD has not yet developed "mature" management concepts for automating the systems procurement process. But, some approaches (AMIS, SAFEGUARD) *have* explored and designed key segments of the process.

A leap of faith might suggest that the cumulative experience of the last 15 years will be sufficient to render workable, practical designs for the systems procurement problem. In favor of such a leap is the observation that systems such as AMIS were not developed in a vacuum. AMIS is sensitive to its sister, ALS, and to the MILSCAP directive itself. It is therefore guided and constrained by existing systems while it pushes forward the state of the art.

Another key element that already exists is the DoD "information utility" (LITE and Avionics Central). The procurement process as detailed in Appendix E of the First Quarterly Technical Report in this project (ARPANET Management Study: New Application Areas, May 1974), relies heavily on such text as ASPR's, the U. S. Code, the Comptroller General's Report, and the Federal Reports. It is gratifying to discover that this material resides in machine readable form, accessible by an advanced (Mead) storage and retrieval system. LITE's extensive library (120 disk packs, soon to double) and Avionics Central's software package would make formidable allies in providing a PAS information utility.

Lastly, and most importantly, OSD has shown clear and consistent interest in fostering the development of procurement automation and managerial streamlining in general. The MILSCAP directive is OSD's catalyst, and although the MILSCAP concept has been obliged to undergo several overhauls, its integrating effects are in evidence in every system that we surveyed.

<u>What's Not Available</u>

Four key ingredients are missing from the PAS concept.

1. The *EXTERNAL INTERFACE* problem needs to be solved; that is, interface standards between contractors and the internal branch MIS. The problem can be viewed in two stages.

a. Insure that firms soliciting business from DoD are required to conform to MILSCAP-type standards in their business communications on contract-related matters. This problem is difficult since DoD cannot, and probably should not, interfere with the internal workings of client firms unless it is in the interest of both parties. As we saw in the DSA case, firms *are* beginning to understand that a reciprocating agreement vis-a-vis business communication is a boon. Confusion, lost paper, delays (especially in payment) are just as unpleasant to the businessmen as to the government. In the case of small business, a one year delay in payment due to a clerical foulup may threaten the entire cash budget and may be costly indeed.

b. A different form of this problem arises in the area of large systems (one of a kind) procurements, which involve the corporate MIS. The government's procurement problems are reflected microcosmically in every large corporation. Compared to the DoD's $50 billion procurement budget, Litton's procurement efforts seem miniscule. However, the Littons of this world have chosen to employ MIS to help cope with the paper flow. It seems rational, and possibly inevitable, that some time in the future *interface* can be achieved between government and private MIS, especially for those activities which involve large continual flows of information. The present system utilizes an intermediary such as the AFPRO to cross the boundary.

2. The *COMMUNICATION NETWORK* problem needs to be solved. While Autodin has been in service for many years providing digital communications for computer systems, it was never designed for the characteristics important to accomodate the full flexibility, fast response time, low cost and channel capacity commensurate with the loads that massive computer netting implies. There appears to be the need for new computer-communications plant capacity more appropriate to the degree of computer netting we believe to be desirable and necessary. More specifically, the procurement activity is necessarily one that is highly distributed geographically. The DoD systems mentioned previously encompass dozens of sites. If the list were enlarged to include smaller offices and the firms themselves, the number might grow to 200-300. Already, several projects have experienced severe constraint in their planning and/or operations due to an absence of adequate cost-effective communication links. An effective DoD-wide procurement system will place a heavy requirement on communication facilities. It is unlikely that a patchwork or ad hoc approach will prove satisfactory to DoD for two reasons:

   a. System reliability and security would be jeopardized by a cumbersome arrangement.

   b. System optimization (hence cost minimization) would be be difficult to achieve.

   The absence of a viable communications network today dampens both the designer's and user's propensity to think in terms of a DoD-wide system. Without this infrastructure, or even a proposal for such a network, the branches correctly feel that inter-system integration is a far-off dream, not an imminent reality.

   An affirmative OSD commitment to the creation of adequate communications facilities would greatly enhance the validity of the MILSCAP directive.

3. The *COMPUTER RESOURCE SHARING* problem needs to be solved. We found that dozens of large computer installations are being utilized in procurement automation. Each center also supports large databases. A rough calculation yields several *hundred* disk packs of active data, backed by several *thousand* archival tapes. New computer resources are being continually purchased, despite increasingly severe budgetary constraints.

The extent of computer-computer communication inherent in a DoD-wide procurement system is a major concern. We feel that OSD would be well-served by making affirmative commitment to the concept of networking DoD computers involved in procurement. The benefits are two-fold: (a) resource sharing would realize tangible economies, and (b) inter-system integration would become a more imminent reality.

4. The *OVERALL SYSTEM ARCHITECTURE* problem needs to be solved. The benefits of bottom-up system design diminish rapidly as the overall system expands. Even at this stage of procurement automation there exist several unfornate areas of incompatibility. Conceptually, OSD has confronted the problem via repeated committment to MILSCAP. Operationally, a design gap has emerged. The procurement automation system as described in this report* and elsewhere ** represents one attempt to fill the design gap.

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*For software and implementation plans, see Appendices A, B, C of this report.

**For hardware architecture, see *ARPANET MANAGEMENT STUDY: New Application Areas*, May 1974, Appendix I.

FIELD SURVEY

A field survey was conducted in July/August 1974 of facilities involved with PAS-type activities. Several sites were not visited in person, hence they appear as somewhat abbreviated reports.

ALS

ALS handles all Air Force logistic procurements. As with the DSA's SAMMS, ALS deals only with "routine" items for which part numbers or stock numbers are known and stable.

The system is implemented in five AF logistic command centers. A close liaison relationship has formed between the ALS and AMIS groups at Wright-Patterson. The liaison is encouraging system integration between the logistic and systems commands, and is accelerating the implementation of MILSCAP directives.

ALPHA and CCSS

ALPHA is the Army's Materiel Command (AMC) MIS. It serves seven major subordinate commands, sixteen depots, four labs, plus 80 other activities; it engages 130,000 employees and manages a materiel budget of around $10 billion. CCSS is an advanced ADP package created to satisfy the broad wholesale support mission of the AMC. It is presently being implemented on a phased basis to allow for system shakedown and integration.

The key functional features of CCSS are: provisioning, cataloging, supply management, procurement, item accounting, maintenance, and financial management. The activity is exclusively devoted to logistic support for the different Army commands.

CCSS is being implemented first at the US Army Aviation Systems Command (St. Louis, Missouri). When AMC releases the system, it will begin implementation at the other six commands--and at that time it will subsume all of ALPHA's present functions.

Table E-3

FIELD SURVEY OF RELEVANT PROCUREMENT AND CONTRACTING SYSTEMS

Short Name	Full Name	Location	Abstract	Contact
ALPHA	AMC Logistic Program, Hardcore Automated	US Army Mtl Command Pentagon	Army materiel procurement	
ALS	Advanced Logistic System	Wright-Patt. AFB Dayton, Ohio	Air Force-wide logistic support system	
AMIS 1975	Advanced Management Information System	Wright-Patt. AFB Dayton, Ohio	Air Force systems command procurement MIS, to track all contracts from the first requirement identification phase through IFB, RFP, contract, and contract closeout	Director of Procurement & Production, AMIS Sol Valentine Cubbert Arnett (513) 255-5126 (513) 255-4006
AC 1968	Avionics Central	Wright-Patt. AFB Dayton, Ohio	DoD-wide info utility, servicing a number of databases such as R&D projects, Navy directives, US Code, Auditor General, ASPR, etc.	Capt. Dan Meiggs (513) 255-6108 Chuck Schneggenberger
CCSS	Commodity Command Standard System	ALMSA St. Louis, Missouri	Extension of the ALPHA Army material for procurement automation; using advanced technology	Ronald P. Uhlig, Chief Science Management Information Systems (202)274-8946
CIAPS	Customer Integrated Automated Procurement System	Pentagon	Logistic automated procurement for base support activities	Richard Shulte (202)697-1137

Table E-3 (Cont'd)

LITE 1964	Legal Information Through Electronics	AF Accounting & Financial Center Denver, Colorado	Text oriented information utility servicing DoD legal offices; databases include US Code, ASPR, Ct. of Claims, etc.	LCOL Rose Valentino Mr. Berthelson (303) 825-1161
MILSCAP 1966-now	Military Standard for Contracting and Procurement	OSD Pentagon	DoD-wide directive for internal and external standardization and integration of procurement MIS	
MOCAS 1965	Mechanization of Contract Administration Services	DSA Alexandria, VA	Tracks all procurement contracts generated by any branch of DoD under the MILSCAP directive	Dante Romano (202) 274-6370
SAMMS	Standard Automated Materiels Management System	DSA Alexandria, VA	DoD-wide logistic support of materiel ordering; related to DCASR's and MILSCAP	H. E. Whitmer Sam Blumberg (202) 274-6378
SAFEGUARD	Management Information System	US Army Huntsville, Ala.	Systems command procurement MIS	

AMIS

AMIS is an advanced weapon systems procurement MIS being developed at Wright-Patterson AFB. It is expected to become partly operational in 1975-6.

AMIS is designed to start tracking a procurement action back at the *requirement* stage. As a requirement is entered into the system, it receives a standard ID, and a "file" is opened. Any AMIS user can, at this point, browse the current requirements statements by date, keyword, etc. Related procurement actions can be reviewed at this early stage by higher level management; and preliminary budget forecasts. The next phase involving AMIS is the *purchase request*. The PR communications are attached to the file and become part of the permanent record. The *solicitation and RFP* information then joins the file. The file remains open until *contract, contract closeout*, and all *delivery, accounting* and *evaluation* information has been included.

The AMIS phase I implementation will begin at the post-contract award. Essentially, all post-contract functions are presently mechanized already. In that manner, AMIS can be implemented with least organizational problems in the field. Phase II will see the other capabilities installed incrementally. At this stage, MILSCAP will be fully implemented in the AF Systems Command.

The AMIS network, as planned, will include 22 Air Force plant representative offices (AFPRO's). The AFPRO's handle all source data acquisition for contract modification, delivery orders, and similar information. The ten major procurement offices in the AF Systems Command will also be on the net. These offices issue and manage the contracts from the pre-award stage until completion. The major communication flows will be between the offices and the AFPRO's Higher level information and communication will go to AFSC/Pentagon, which is also slated to be on the net.

The extensive networking capability, in full interactive mode, places a serious demand on communication facilities. At this point, the Communication Command is studying the AMIS communication needs, and anticipate a recommendation within the year. The original OSD suggestion involved using the ARPANET. But as a result of network congestion, ARPA decided that they could not possibly support 32 new nodes in a service capacity. Plans have therefore been remade to include all options: ATT/DDS, SCC's and so forth. Although message switching seems to have been ruled out, the actual communications technology (point-to-point, packet etc.) is still an open question.

AMIS plans to continuously upgrade the system after it goes int Phase II. Such attractive features as *graphics* are said to be "on the drawing board" for the future. (However, this may be beyond the state of the art according to our own investigations.) In general, AMIS seems to be in close harmony with the spirit and intent of the Procurement Automation Systems proposal

Avionics Central (AC)

Avionics Central is a DoD-wide information storage and retrieval utility. The system maintains about 12 text-oriented databases.

Avionics Central uses the Mead Data Central Software package. The actual database definitions and specialized output formats are written by the small five-man AC shop. In addition, AC handles file management functions, including conversion, updating and so on.

AC enjoys a close personal working relationship with Mead Corp. The Mead software, which cost 50 man/years to develop, is generalizable for a wide variety of databases. AC has written special purpose output formats, arithmetic search routines, and a text editor. The terminals are leased from Mead, and include a color display, controller and keyboard. Presently, the hardware rents for $420/month, although Computer Communications, Inc. (CCI, Inglewood, Ca.) is producing a new model that rents for $170/month. In addition, 75 terminals around the country tie into the AC system (plus one in Iran, a demonstration using satellite communication.

A note on the software: the software occupies 120K bytes in core, plus 2K bytes for each device type, plus 756 bytes per user.

Avionics Central's active files relevant to procurement automation are:

1. MASIS (Management and Scientific Information System). Contains *all* DoD's R & D projects -- status, scope, objective, approach, funding levels, major output. Andrews AFB sends a bi-weekly update tape, typically containing 2000 items. A production conversion program updates the files. User community: 12-14 laboratories.

2. Navy File. Contains DoD directives, Secretary of Navy directives, Naval operation instructions, three titles of the US Code, Navy Regulations, Abstracts of Naval Training courses.

The updates come as hard copy, often keypunched in Korea. Some data comes in MTST. In addition, AC is installing an on-line text editor for remote updating.

They charge $1700/man month for keypunching and verifying. The Korean charges are $1100/million characters for punch-and-verify. The programming time is charged at $3000/man month. For example, the Linotron tape for Navy Abstracts cost two man months to convert.

3. The *Auditor General*. Three files: library, plan and report. Updated weekly or more. The source is OCR input, done in-house at Wright-Patterson.

4. Procurement Action Schedule: (PAS). A base-oriented manpower scheduling system. Projects manpower levels and commitments over all Wright-Patterson base projects for 1974-5.

5. ASPR. AC receives a Linotron tape which they process through a production conversion program. The ASPRs are current within one week after the tape is issued by the DoD's ASPR Committee. The ASPR database is intended for government use *only*. All contractors are required to enter their requests through a government agency. ASPR serves a user community of around 300 and is used often.

6. Commission on Government Procurement. Documents of the Commission. This file was taken down recently for lack of user demand, but exists on a library tape.

7. Facilities. All equipment, special rooms, labs, etc. A Whole Earth Catalog for DoD resources.

CIAPS

CIAPS is exclusively an AF base support procurement system. Its domain includes all pre-priced contractural arrangements. Its supply functions include automatic ordering and inventory control, much the same as DSA's SAMMS system. CIAPS also provides several service functions such as contract maintenance (e.g. repairs, warranties), and might contain on-line information on labor regulations, wage rates and the like.

CIAPS is distinguished by being AF-wide, *base* support only, for items requiring no negotiation. It is fully coordinated with DSA acitivities.

LITE

Lite is a government-wide information utility. DoD serves as the executive agency for the Federal government, the AF is the executive agency for DoD, and the AF Accounting and Financial Center at Denver does the work. The system has been in operation since 1964.

The most widely used databases are the Court of Claims, Comptroller general's decisions, and the ASPR's. A complete list appears in Figure E-4. LITE is planning to put on the *Federal Reporter* and *Federal Supplement* in Fy75, plus a few other systems. LITE expects its demand to double when the *REPORTER* and *Supplement* come on.

Lite is a very small shop. Three attorneys frame the search requests. There are two more lawyers at the top level, plus a small secretarial staff. The computer center host is contracted, as are all the keypunch operations.

LITE contracts out all its keypunching. In FY74, they spent $441,000 to convert text into code (compared to $409,000 for their

Table E-4

CURRENTLY* SEARCHABLE DATABASES IN LITE

ASPR Jan 69 thru CH 3 (thru 30 Jun 1969)

Board of Contract Appeals Vol 71-1, 72-1 (Jan 1971 to Jun 1972)

CMR - COMA Decisions Vol 1-46 (Dec 1951 to Jun 1973)

CMR - BR Decisions Vol 1-45 (Dec 1951 to Jul 1972)

Dec of CG Vol 1-51 (Jul 1921 to Jun 1972)

Dec of CG (Unpub) Jun 1955 to Jun 1973

Manual for Courts-Martial, 1969 Rev Ed

Pub International Law Agreements (Jun 1949 to Aug 1973)

Unpub International Law Agreements (Jun 1947 to Dec 1973)

U.S.C. 1970 Ed thru Supp II Titles 1-50 APPX (Jan 1971 to Jan 1973)

U.S.Ct of Claims Rpts	- Contracts	Vol 134-183	(Jan 1956 to Apr 1968)
	- Pay	Vol 134-183	(Jan 1956 to Apr 1968)
	- Taxes	Vol 134-183	(Jan 1956 to Apr 1968)
	- Misc	Vol 134-183	(Jan 1956 to Apr 1968)

U.S. Ct of Claims Rpts - Vol 184-187/195-197 (May 1968 to Mar 1969 and June 1971 to Mar 1972)

U.S. Reports Vol 342-403 (Oct 1951 to Jun 1971)

U.S. Reports Vol 409 (Jul 1972 to Jan 1973)

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*As of 1 July 1974

operating and maintenance budget). As yet, *none* of their source material comes as machine-readable format, except the ASPRs.

LITE cannot recoup its keypunching costs by selling tapes to other users, for two reasons:

1. The publishers of the other publications (such as *U.S. Reports*) forbid them from secondary sales since they are afraid of losing sales on books. LITE people feel that sale of books would *increase,* because a computerized index would be a great service.

2. They are sensitive to commercial markets in the legal-search business, and are loathe to intervene in that market in any way.

In fact, LITE refuses to serve *any* private (non-government) client, even prime contractors. If primes want to access a database, the request is funnelled through the government agency involved.

LITE uses two-360-65's under OS/MVT A typical pass through a file takes 25 seconds of CPU time. No file is bigger than '.5 million words on disk pack.

LITE typically uses six 29 million words disk packs per file, plus two more for a dictionary. The dictionary is composed of all words in the file except throw-aways such as "a, and, in the ... ". The ASPR's is the *smallest* file they maintain, taking only two disk packs.

The whole operation is batch. LITE's management doesn't feel that they can justify interactive RJE on the basis of their early experiences. LITE apparently experimented with having users frame their own questions and submit their own jobs. To that end they held tutorial sessions. The experiment ended because the users couldn't learn the system. Also, they think that the entire database is too large to put on-line. They now employ 120 disk packs, and expect to go to 250 packs when the *Federal Reporter* goes on. Also, the lawyers feel that browsing text in an interactive mode is unsatisfying for two reasons (1) costs too much money in connect time, and (2) the human factor problems introduced in reading a CRT for many hours per day. However, on an experimental basis they are now arranging to hook up with Justice Department's interactive JURIS system. Select LITE files are being put on DoJ computers, and if the experiment is a success, LITE in Denver will open its shop for RJE. The evaluation will be published in '75.

The LITE user community is 60% DoD attorneys, 40% other attorneys, contracting officers, etc. About 40% of their requests are procurement oriented. Last year, the Office of the President called once, and Congress called twice. Typical turnaround: question *in* before 2:30 P.M., output in airmail next morning.

The LITE unit receives 2000-3000 search requests/month. This number is expected in double in 1975, and double again in 1976. Each output is accompanied by an evaluation form (see Figure E-2). A random sample of the last six months (50 returns) showed the following.

Found relevant material or that none exists	43
Found relevant material but missed some important material which you know exists in the LITE data bank	3
Totally missed relevant material which exists and is in the LITE database which was searched	2
Hours required using conventional indexes	15 1/2 hrs

MOCAS

MOCAS is a DoD-wide contract management system. When a contract is awarded by any branch of DoD, a hard copy goes to the appropriate DCASR (Defense Contract Administrator Service Region). In addition, selected relevant contract information is fed into a centralized database at the DSA. The usual procedure for data entry is OCR; in addition, data can be streamed through AUTODIN.

Each regional DCASR has a computer, typically Honeywell 2060's, 2070's, 2200's, 1200's. They share *one* centrally produced software package sent from a programming shop in Columbus, Ohio. The software updates come either in magnetic tape load modules, or transmitted via AUTODIN.

The LITE System is intended to supplement conventional systems of indexing. To help improve future service, please answer these questions on the usefulness of LITE to you. Thank you.

1. Date and time you received printed search report. 7/15/74 10⁰⁰ AM

2. Was the search for: a specific case ✓; general research ___; a course you are taking ___, or teaching ___; other unusual or special ___.

3. a. Was the source material searched available in your library? ✓ Yes, ___ No, ___ Partially
   b. Would the research have been reasonably feasible in your office using a conventional printed index, rather than the LITE computerized index? ___ Yes ___ No ✓ Partially
   c. Please estimate the number of hours required using conventional indexes. 160

4. How effective was this LITE search in terms of your needs?

   a. ✓ Found relevant material or that none exists.
   b. ✓ Found relevant material but missed some important relevant material which you know does exist and is in the LITE data bank.
   c. ___ Totally missed relevant material which you know does exist and is in the LITE data base which was searched (See page 1 of search reports.).

5. Remarks

AFAFC FORM APR 74 T-84

Please fold on dotted line, staple or tape, and mail.

75-0043
4

Figure E-2. A user evaluation system for LITE
(Notice time estimate, Question 3c.)

The procedure for using MOCAS is as follows:

1. MOCAS may be consulted archivally *before* a contract is awarded to establish past performance records for individual contractors.

2. When a contract is awarded, selected information is put into MOCAS. This includes the PIIN number, quantity ordered, item description, price, delivery information, contractor name and address, etc.

3. As the contractor ships, evidence invoices come to the DCASR, and MOCAS receives the update information.

4. The contractor forwards invoice for payment; the invoice is compared against the original contract and the shipping invoice; if all is well, the checks are automatically authorized and issued.

5. When the contract is closed, all the information is archived.

6. MOCAS is used to generate a large variety of higher level management information, such as histograms of order amounts, quotas of SBA's, etc.

The MOCAS philosophy is to build by small evolutionary steps, not plunge in with big systems. Following that line, MOCAS has won the respect and use of all DoD agencies. In plain language, they get the job done.

They have concentrated first on *internal standardization* of contract information. Most contracts now use the same field formats and include similar information so that the coordination job between DoD branches has been greatly reduced. In addition, MOCAS is now concentrating on external standardization, between the government and contractors. This task is still under way, and "significant" improvements have been made. Obviously, it is much more difficult to ask the private sector to conform to invoicing and billing standards, but as the contractors learn that MOCAS is good for them (i.e. prompt payment), their willingness to cooperate increases.

The MOCAS design and implementation fully anticipates the MILSCAP directive. That is, when and if OSD decides to fully implement MILSCAP, the MOCAS system will not have to be dismantled or seriously altered. At present, the Army, Navy, and Air Force have implemented their versions of MILSCAP into their own systems, but differences still exist between branches. DSA feels that MILSCAP will be implemented later this year, and that MOCAS is ready for it.

When MOCAS turns into a MILSCAP system, several noteworthy features will be introduced.

1. In addition to basic contract information an *abstract* of the procurement action will be produced and included in the database. This implies text editing features of a fairly sophisticated nature.

2. All aspects of the contract administration will be included, such as amendments to shipment and payment data, and memos between the purchasing agent and the DCASR.

3. More extensive use of networking is envisioned, especially for RJE updates from the field.

SAMMS

DSA discovered that 90% of their purchases are under $2500, and that the overhead costs on these purchases consumes 80% of their budget. The agency correctly chose to concentrate their resources on automating the small purchase first. The sheer number of the procurement transactions is impressive. SAMMS serves six major supply centers which are functionally divided and mutually exhaustive (an item is uniquely assigned to a center). They are: construction, electronics, fuel, general, industrial, and personnel support centers. *Each* center generates about 3/4 million small (under $2500) procurement transactions per year. In addition to the supply centers, there are four depots, five service centers, 11 DCASR's, and some 3000 field offices scattered world-wide. The flow of information into SAMMS is an impressive event, since it is funnelled from field office up, and reports are funnelled back out to the field. The information is standardized, and machine readable. Some field offices send in cards, some come through AUTODIN, some is OCR.

SAMMS is composed of five software modules. Each functionally separate module is made up of numerous routines and special purpose programs. SAMMS undergoes continual revision and expansion in order to meet changing management needs.

SAMMS's success can be gauged in a number of ways. First, they have reduced the overhead cost from 35% of the procurement dollar on buys up to $250 down to 4%. Similar cost reductions are being experienced in the $250-$2500 range. Second, an OSD Procurement Task Group is seriously looking at SAMMS as the model for mechanization of logistic support procurements.

SAMMS is moving into phase II as soon as the software becomes available. The next phase will see several improvements: (a) a solicitation will be automatically issued, based on inventory flag points (b) the software will automatically select the appropriate vendors (c) an RFP will be composed and issued automatically. DSA expects to have phase II operating in about 6 months.

SAMMS is intended to conform to MILSCAP standards, even though MILSCAP is addressed to procurements *over* $2500, and SAMMS is presently restricted to under $2500. The conversion programs to make SAMMS fully compatible with MILSCAP (i.e. in the sense that MOCAS will be compatible with MILSCAP) are said to have already been written.

APPENDIX F

GOVERNMENT PROCUREMENT: A CASE STUDY IN THE ECONOMICS OF INFORMATION

by

Marc U. Porat

INTRODUCTION

This appendix was prepared jointly for Cabledata Associates and for a Stanford University seminar on the Economics of Information.

The paper provides an economic background for the needs of the Procurement Automation System concept. Five main arguments are presented:

1. Government procurement is a significant activity in the U.S. economy.

2. The procurement process is characterized by numerous "non-market" phenomena.

3. The procurement system is highly information-intensive; information is an important structural component.

4. Many "failures" of the procurement system can be traced to informational problems.

5. Remedial solutions to such failures should occur at the structural level, not at the behavioral level.

WHY PROCUREMENT?

The economic significance of procurement can be appreciated in various ways. In FY 1972, the Federal government procurement activities consumed $57.5 billion of a $237 billion budget (Table F-1). When that figure is combined with the $39.1 billion in federal grants, the amount itself is staggering (Figure F-1). Procurement is a major activity of government, yet it has received scant attention from economists. In the past twenty years only a handful of books have been published on the subject and scarcely more articles. The Federal government has taken a few looks at itself through various Commissions, but not until last year's *Report of the Commission on Government Procurement** was an in-depth study produced.

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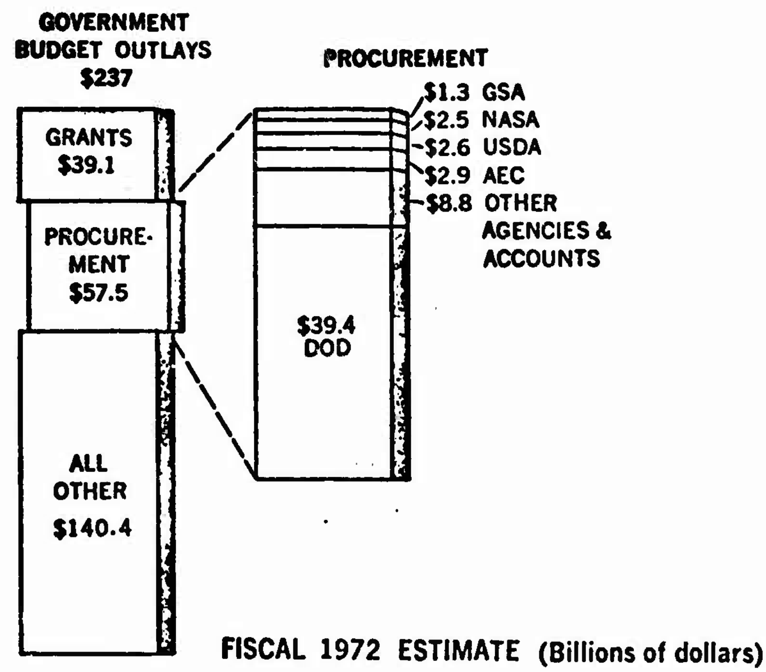
*Commission on Government Procurement, *Report of the Commission on Government Procurement*, 4 vols., Washington, D.C.: U.S. Government Printing Office, 1972.

Table F-1

TOTAL ESTIMATED GOVERNMENT PROCUREMENT, FISCAL YEAR 1972

Agency	*(Billions of dollars)*	*Tota*
Department of Defense [a]		39.3
Civilian executive agencies [b]		
Atomic Energy Commission	2.88	
Department of Agriculture	2.62	
National Aeronautics and Space Administration	2.48	
General Services Administration	1.31	
Veterans Administration	0.74	
Department of Health, Education, and Welfare	0.72	
Department of Transportation	0.70	
Department of the Interior	0.65	
Department of Labor	0.38	
Department of Housing and Urban Development	0.25	
Tennessee Valley Authority	0.23	
Department of State	0.20	
Department of Commerce	0.17	
Department of the Treasury	0.16	
Other agencies	1.00	14.4
Other expenditures which should be classified as procurement		
Executive printing by GPO [c]	0.18	
Blind-made products [c]	0.02	
Government bills of lading [d]	1.05	
Government transportation requests [d]	0.28	
Commercial utilities and communications [c]	1.50	
Rents paid by GSA [e]	0.51	3.64
Total estimated Government procurement [f]		57.48

[a] U.S. Department of Defense, Office of the Secretary of Defense, *Military Prime Contract Awards and Subcontract Payments and Commitments, July 1971–June 1972;* and Commission Studies Program.
[b] U.S. General Services Administration, Office of Finance, *Procurement by Civilian Executive Agencies, Period July 1, 1971–June 1[illegible] 1972;* and Commission Studies Program.
[c] Estimated by the Commission.
[d] Information furnished by GAO and Commission Studies Program.
[e] Information furnished by GSA and Commission Studies Program.
[f] Does not include salaries of personnel engaged in procurement activities.



Sources: Appendix I.
The U.S. Budget in Brief, Fiscal Year 1973, Office of Management and Budget, table 8, Budget Receipts and Outlays, 1789–1972, p. 85.

(Secondary source: Report on the Commission on Government Procurement, vol. 1, p. 3.)

Figure F-1. Procurement and the National Budget.

The procurement activity itself is noteworthy in two respects: (a) it is distinctly a "non-market" phenomenon; and (b) it is information-intensive. It is an important part of the Federal government's impact on the economy. The Commission Report points out that procurement activities are "thought to generate some three times their amount through multiplier effects in secondary and related spending."* Some examples of these effects are indicated in Tables F-2 and F-3. It is an activity which comes under perennial Congressional and public attack; it is suspected of providing a feeding-trough for wasteful corporations and of harboring private empires at the public expense. It is accused of being a corrupt and corrupting activity, one that is so complex and Byzantine that only the "insiders" can be close enough to understand it. It is held responsible for generating mountains of red tape, bureaucratic mazes whose purpose is to maintain the bureaucrat's position, and for generating misunderstood and badly managed projects that account for billions in wasted dollars.** The sad part is that these criticisms are all too often true. Despite the boondoggles and evident irrationalities, and despite the immensity of the activity itself, the procurement process has not been closely scrutinized by economists. It is, however, an essential part of our government and our national well being. Procurement is a process often involved with public goods, often utilizing and extending state of the art technology, often creating whole new industries as spin-offs. It is an activity which absorbs the energy of 80,000 government employees, dozens of government agencies, and an increasing amount of the tax dollar.

The procurement process is involved with all government purchases -- from wrenches to rockets. Within the Department of Defense, for example, of a $37 billion procurement bill for 1973, $30 billion involved procurement worth over $10,000. These procurements comprised only 177,000 of the 10,490,000 transactions

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*Ibid., Vol. 1, page 3

**Ralph Nader, *The Monopoly Makers*

Table F-2

PERCENTAGE OF INDUSTRY SHIPMENTS TO THE GOVERNMENT, 1967

Product line	*SIC classification*	*Shipments to the Government (%)*
Food and kindred products	20	1.2
Tobacco manufactures	21	3.5
Textile mill products	22	1.1
Lumber and wood products	24	0.9
Furniture and fixtures	25	2.0
Paper and allied products	26	0.8
Chemicals and allied products	28	1.5
Petroleum and coal products	29	1.5
Rubber and misc. plastics products	30	2.6
Leather and leather goods	31	4.2
Stone, clay, and glass products	32	0.8
Primary metal industries	33	1.1
Fabricated metal products	34	3.2
Machinery except electrical	35	3.4
Electrical machinery and supplies	36	14.0
Transportation equipment	37	28.2
Instruments	38	11.1
Miscellaneous manufacturing	39	2.0

Source: Percentages calculated by the Commission from data in *1967 Census of Manufactures*, Special Report, Distribution of Manufacturers' Shipments and Sales by Class of Customer, Department of Commerce, May 1971, table 1.

Table F-3

PERCENTAGE OF SALES TO THE GOVERNMENT BY WHOLESALERS AMOUNTING TO MORE THAN THREE PERCENT OF TOTAL SALES

Product line	*SIC code.*	*Sales to the Government (%)*
Dairy products	5043	7.8
Electronic parts and equipment	5065	5.7
Transportation equipment (excluding motor vehicles)	5088	4.7
Printing and writing (fine) paper	5096	3.3
Commercial machines and equipment	5081	3.3
Amusement and sporting goods	5099	3.1

Source: *1967 Census of Business*, Wholesale Trade Sales by Class of Customer, Department of Commerce, Sept. 1970, table 1.

during that year. That is, around 2% of all procurement actions involved 80% of the money. The big ticket items, such as major construction and weapons systems, are by necessity enormously complex enterprises. Their very complexity introduces a tangible cost into the system in terms of uncertainty and lack of coordination. The big payoff in studying the procurement process resides in understanding how to manage such large projects successfully. Management and decision making at this level are uniquely information-intensive activities. Therefore, this paper will focus on mainly large-system procurements from an informational perspective.

THE NON-MARKET NATURE OF PROCUREMENT

In a "pure" neo-classical market, supply, demand, and price play crucial roles. The producer, facing a known supply function, decides to raise capital and bring a product to the marketplace. The product price and characteristics are chosen to maximize the return to the producer's efforts, and are highly affected by consumer tastes. The producer normally takes action, in the form of advertising, which is designed to affect consumer preference in favor of his product. To the extent that this process is successful, consumer preference and the producer's supply possibilities will be matched by the producer to achieve maximum profits. The consumer exercises his preference by spending money, and this currency is the information medium of the market. The market is, primarily, an information system. The producer and consumer match tastes and means and conduct their transactions in the most efficient manner possible. Prices of goods are supposedly determined by competition between sellers and by the consumer's marginal willingness to pay. Decision making is assumed decentralized and responsive to changes in the market conditions.

The procurement "non-market" works very differently. First, it is the buyer, not the seller, who takes the initiative to develop a product. The government agency, through internal means, will recognize that it has a need, and will move to interest suppliers. The risk capital is supplied by the consumer, not by the producer -- although in some cases the producer and consumer will share the risk in some measure. The supplier is discouraged (and sometimes disallowed) from advertising, on the assumption that the consumer knows what it needs without undue influence. The consumer often pays for the product before it is completed, and if dissatisfied must pay the full cost anyway. Decisions are centralized in the bureaucracy, and normally there is a monopsony. Price is very often not the determining feature of the decision, with variables such as timeliness and quality taking precedence; in some extreme cases (such as the Polaris missile) price is an almost irrelevant constraint. Consumer preference is revealed through a long non-monetary process, and often the object of procurement is to help crystallize preference.

This is not to say that a market does not exist, but that a neo-classical market does not exist. The distinction is crucial, since, if we assumed the former, then structural changes designed to alter incentives and performance would be misapplied and inappropriate. It is also not a unique market. As our economy becomes more complex, more highly organized, better coordinated, the emergence of centralized planning, often with government as a key actor, becomes more widespread. As such, the assumptions of the neo-classical market are less applicable, and a new or revised set of assumptions are in order.

UNCERTAINTY AND RISK

Scherer and Peck, in their definitive study on the weapons acquisition process, state their major thesis as follows: "the weapons acquisition process is characterized by a unique set of uncertainties which differentiate it from other economic activity."* A large procurement, such as a weapons system, is fraught with uncertainty at all levels of the process.

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*F.M. Scherer and M.J. Peck, *The Weapons Acquisition Process: An Economic Analysis* (Boston: Harvard University, 1962), p. 17

Buyer Connected Uncertainties

The sponsoring agency is itself source of uncertainty. Its role is to identify needs and issue IFBs (Invitation for Bid) and RFPs (Request for Proposal). The agency ostensibly knows what it needs, or at least knows enough to frame the right questions. The procuring agency has much to be uncertain about. First, has the need for procurement been clearly established? This decision is based upon the expected cost of procuring additional capability, and the evaluation of current equipment. What is the optimal equipment? Should it terminate a marginal project? These decisions require data which may be unavailable or highly subjective.

The agency is uncertain about its budget for the next fiscal year. This uncertainty causes it to adopt budget practices that are "tentative"; many projects are only partially funded during the current year, and some may come into jeopardy due to unexpected variations in the budget process. Table F-4 provides examples of the range of alternatives used to cope with this uncertainty.

The agency is uncertain about technological change. The state of the art may be radically altered during the course of the project, rendering it embarrassingly obsolete before it is even operational. The state of the art may not be as mature as the agency had anticipated, causing delay and cost overruns.

The sheer complexity of administering technologically sophisticated projects adds to the uncertainty. A large project such as the Apollo Mission may have millions of separate technical tasks to accomplish. Each is internally plagued by uncertainty. In addition, the coordination problem between the various project tasks is a source of uncertainty. Elaborate management tools such as PERT have been developed to try to cope with this problem. Such management systems severely tax the information handling capacities of the organization.

The external political environment is a source of uncertainty. Sudden political or military developments may occur, causing the agency's timetable to undergo massive upheavals. This occurred within the Office of Education after the 1957 Sputnik launch. In

Table F-4

MULTIPLICITY OF PROCUREMENT OPTIONS AFTER FIRST REVIEW

Case A

(1) Accept the system as proposed by the service.
(2) Cancel and undertake development of a new system for joint service needs.
(3) Cancel and rewrite requirements.

Case B

(1) Proceed with proposed system using prototypes.
(2) Modify existing inventories instead.
(3) Cancel and do more studies.

Case C

(1) Approve two systems as proposed by services X and Y.
(2) Approve system X and cancel Y.
(3) Approve system Y and cancel X.
(4) Cancel both and develop joint requirements.

Case D

(1) Proceed with system without prototypes.
(2) Proceed with system with prototypes.
(3) Cancel and upgrade existing inventories.

Source: Development Concept Papers, abstracted for purposes of declassification.

projects that require long lead times, such sources of uncertainty can be very troubling.

A commercial enterprise has well defined objectives, such as profit, by which its progress is measured. Government agencies, by contrast, cannot be held accountable by simple metrics. The agency is beholden to a public master, the Congress, whose requirements are pluralistic and political, and whose purposes and intentions are not always clear at the outset. The procurement process is influenced by this lack of objective evaluative criteria.

Uncertainty in the program decision has two sources: whether a particular weapon system being sought is feasible (given time, cost and quality constraints); and uncertainty about the ultimate reliability and usefulness of the procurement. The shape of the trade-off curve in Fig. F-2 is fuzzy. In the 1940's and 1950's, weapons acquisition often failed to attain its goals due to rapid changes in international relations, military strategy, technology, prices, and organizational changes. It is reasonable to expect this state of uncertainty to continue in the future, especially in the case of large-system projects. These conditions cast a doubtful light on the real value of rational optimization techniques.

Uncertainty is present throughout the weapons acquisition process, but in different degrees. It is most severe during the early phases of program development, when the system designers face a "blank sheet of paper." However, "most of the uncertainties are dispelled more or less effortlessly as the passage of time unfolds information which previously could only be guessed. But internal uncertainties are consciously reduced by the development process itself; for development is essentially a process of *generating knowledge*."* The major costs are incurred at a time when most of the uncertainty has been resolved. Clearly, each dollar spent in reducing the uncertainty at the early stages pays off handsomely at the later stages of the process. (See Figs. F-3, F-4 and F-5).

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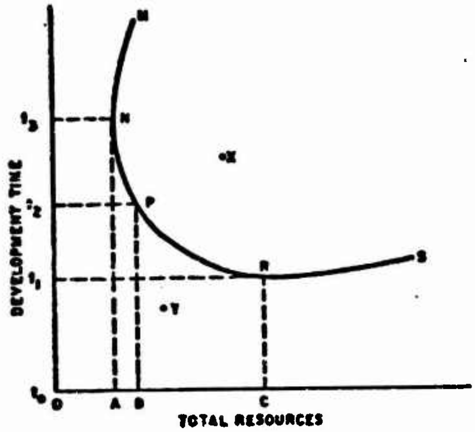
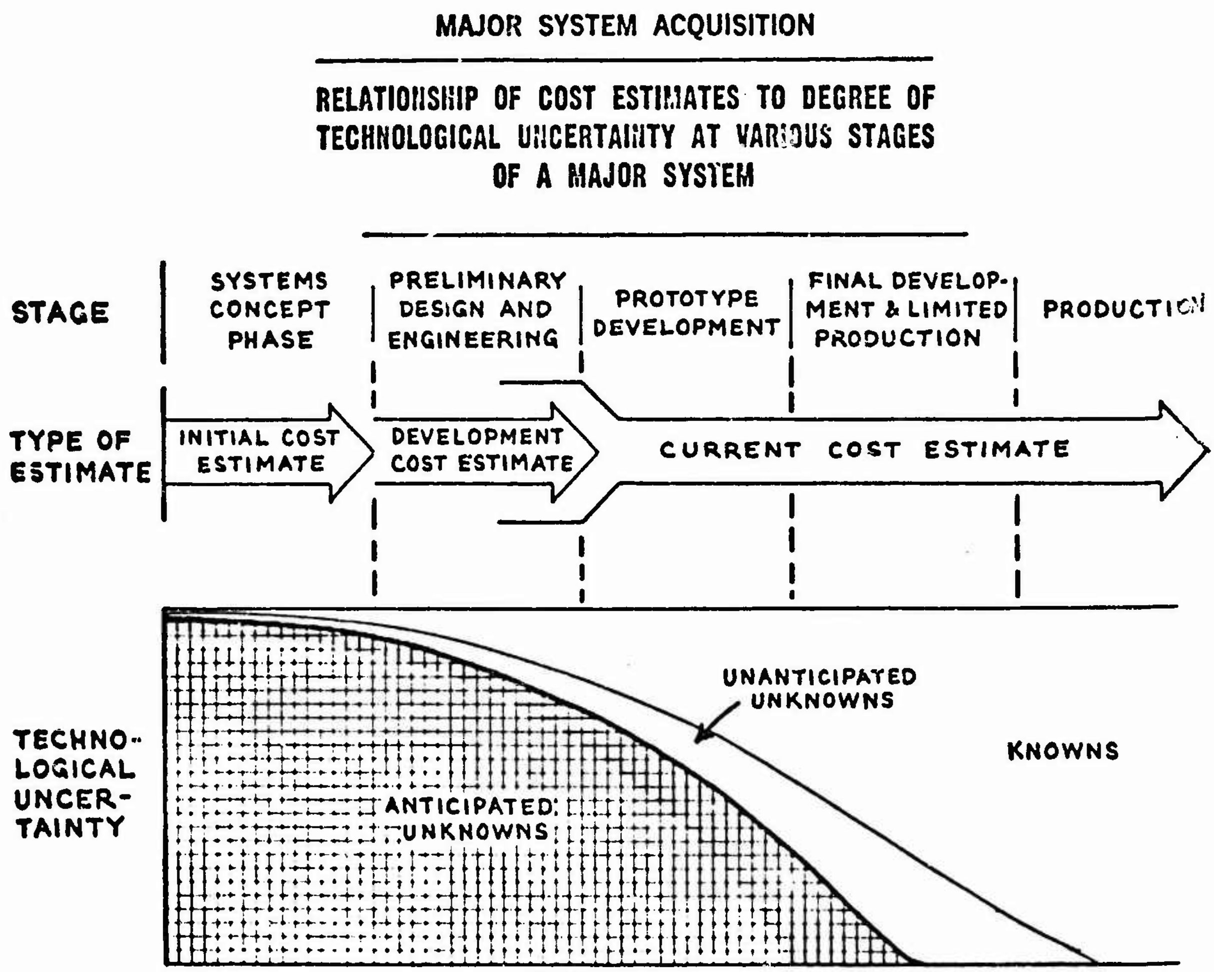
*Ibid., p. 187



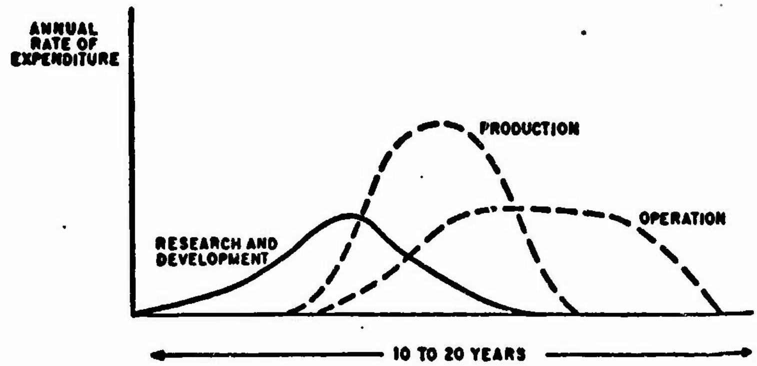
Source: Scherer and Peck, p. 255

Figure F-2. Tradeoff between time and resources



Source: Commission on Government Procurement Report
Commission Studies Program.

Figure F-3. Declining uncertainty as a function of time



Source: Scherer and Peck, p. 310

Figure F-4. The flow of expenditures in a typical weapons program

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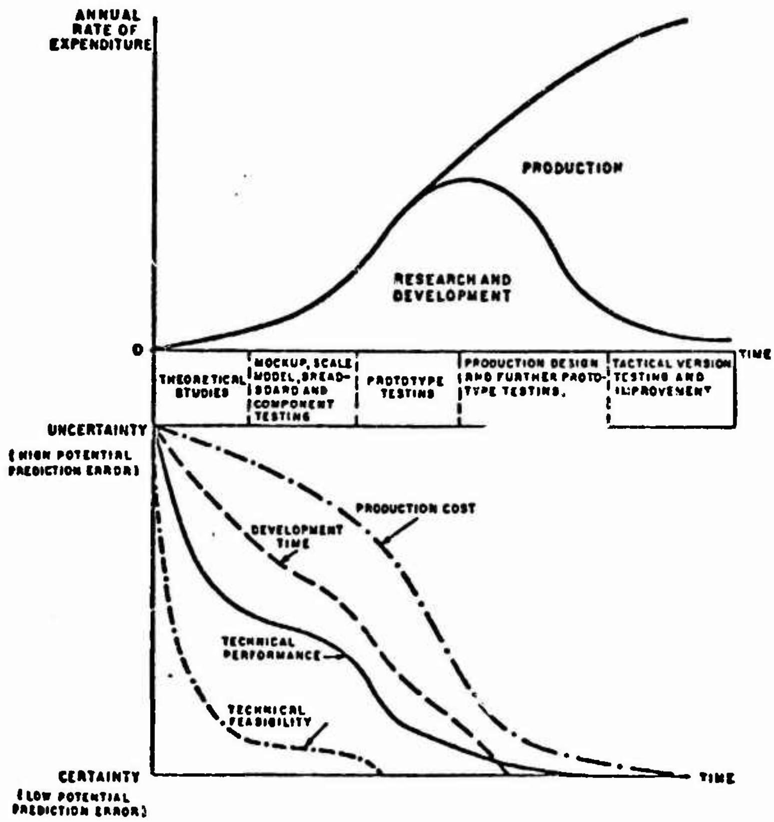

Source: Scherer and Peck, p.313
Figure F-5. The relationships among time, expenditures and uncertainty

Bid Connected Uncertainties

Procuring agencies use different techniques for evaluating proposals, especially when the product has multiple attributes. The agency's tradeoffs between price, quality and time are usually not revealed to the bidders. The agencies:

> fear such disclosure may result in the buying officials and the sellers relying too heavily on the mechanics of the scoring system instead of using their own judgment. They also believe that the Government might aware contracts to inferior firms which had a slightly higher "score" than a superior competitor, that competitors might be inhibited from submitting innovative ideas which did not agree with the evaluation criteria, and that GAO might be inclined to uphold protests on the ground that award was not made to the competitor with the highest score.

These observations should strike neo-classicists as being exactly backwards. In "normal" markets, the seller makes deliberate effort to deduce the consumer's preferences with respect to product characteristics. To the extent that this costly process is not an attempt to impose on the public the "appropriate" criteria by which the product is to be judged these criteria are part of the overall market strategy of product differentiation. Yet here we have a direct negation of the practice. The Commission concludes that "...the weakness in these observations is that neither the law nor common sense supports the likelihood of their occurrence. Nothing could be more basic to sellers than knowing what the buyer really wants. Without knowledge of the relative importance of the evaluation criteria, sellers can determine only partially what the procuring agency considers important."**

Lastly, the procurement process itself is a cumbersome device. The sheer number of informational transactions that are required can cause delays and obstruction at many points in the process. The importance of timeliness and coordination cannot be overstated,

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*Commission, op. cit., Vol. 1, p.25

**Ibid., p.25

and any forces that militate against these attributes cause uncertainty.

Supplier Connected Uncertainties

The competitive bid process introduces massive uncertainties for the firm. On the one hand, it tries to respond to signals generated by the procuring agency; the act of responding to a bid is already an investment of scarce technical and managerial talent in an activity which may return nothing. On the other hand, the firm tries to influence the agency to develop commercially interesting products, since the expected profit on projects that continue beyond the R&D stage is significant.

The supplier is uncertain about the right amount of risk capital that it should invest. There is some evidence that it does not commit enough, and that this decision is costly to the firm and to the government.*

Turnover amongst defense contractors is much higher than in the general business environment. This might reflect the uncertainties associated with defense work. This condition makes inter-firm coordination more difficult, especially in large contracts that may involve four or five tiers of sub-contractors. There is some evidence that procurement personnel themselves have a higher turnover rate than average. This loss in cumulative experience is costly to the firm, and increases the probability of error.

An interesting characteristic of the products which DoD procures is that they are extremely complex in their operation and maintenance. Therefore, a "User's Manual" is necessarily a joint product with the actual system being procured. The product data, as it is called, is an information product, but its cost can sometimes surpass that of the product itself. Typically, a vendor will be required to furnish maintenance and operation manuals, replacement parts lists,

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*Ibid., pp. 69-70

and inspection or quality control data. The specs defining what data are required are voluminous in their own right. The cost of the information is staggering -- the Blue Ribbon Defense Panel found that the DoD spent $4.4 billion in 1969 alone.* What is lacking is a streamlined method of packaging the data for future use such that it is readily understandable by future generations of users and systems builders.

Another interesting feature of the products is the unusually high informational input that is required.
The services of architects, engineers, computer programmers, management consultants, social scientists, system analysts, and R&D labs consumed $9 billion in 1972 and engaged over 10,000 firms.** (See Table F-5). Information is an anomalous input, unlike matter, energy, capital, and labor. For example, the act of consuming information does not necessarily deplete its economic service. The value of information does not necessarily decrease with its use, although once produced, its marginal cost tends toward zero. The procurement process, which relies so heavily on information (15% of total expenditure), is thereby burdened by the anomalous character of the input. Problems in appropriability immediately come to mind. The information, once revealed, can be used by others quite freely unless protected by copyright or patent. But procurement is a public expenditure, and theoretically all aspects of the good should belong to the public. If the pure case were followed, however, the commercial incentive would disappear for firms engaging in "knowledge creation" slated for market exploitation.

Coordination Connected Uncertainties

Most large procurement projects cannot be handled by one firm. Therefore, coordination mechanisms must be employed to deal with budgeting, material, personnel, technology, and timing problems.

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*Ibid., p. 81

**Ibid., p. 97

Table F-5

THE INFORMATION INPUT IN PROCUREMENT

Type of service	*No. of firms*	*Total revenue (billions)*	*Percent of revenue*
Architect-engineer	6,300	$3.60	40
Computer software (analysis and programming)	1,800	2.70	30
Management consulting and social sciences	2,000	1.35	15
Systems analysis	250	1.08	12
Research and development (mainly laboratories)	100	0.27	3
Total	10,450	$9.00	100

Source: Memorandum of interview by representatives of the General Accounting Office with officials of The National Council of Professional Services Firms in Free Enterprise, Oct. 4, 1972.

The flow of information necessary to deal with coordination grows exponentially with the number of firms involved.

Entry into procurement business is not difficult. Scherer and Peck concluded that economies of scale in preparing, presenting, and "selling" the RFP were not sufficient to preclude new entrants. This is also true for administrative functions such as legal services, public relations, personnel and so on.*

Rapid technological change has tended to lower barriers to entry. Small firms with specialized talent can often come up with a winning proposal. The procurement agencies understand this, and discourage "shopping around" for information from small firms with the intent of giving the final job to larger companies. Very rapid technological change, such as we have experienced in the data processing and communication industries, tends to equalize entrant prospects. This is especially true in procurements that involve divisible products or processes.

Scherer and Peck conducted a study on the attributes of procurement objectives, and concluded that "maximizing quality" (state of the art exploitation) was slightly more important in weapons programs than minimizing development time, which in turn was much more important than minimizing development cost. Some of their findings are shown in Figures F-6 through F-10.

One way of maximizing the dollar return on the information gathering activity, and to acquire the information more rapidly in cases where the technology or external uncertainties are volatile, is to pursue a *multiple approach* to research and development. By funding multiple but related R&D projects, the procurement agency can maintain greater flexibility in its final choice. It may be cheaper to fund only one project, but in the event that it should fail to meet the system requirements, the agency will have to fund a new project at a highly accelerated spending rate and on a crash program basis. Crash programs, leaving very little time slack for on-going evaluation and re-design, are by far the greatest contributors to cost overruns and generally give unsatisfactory performance.

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*Scherer, Op. cit., p. 187

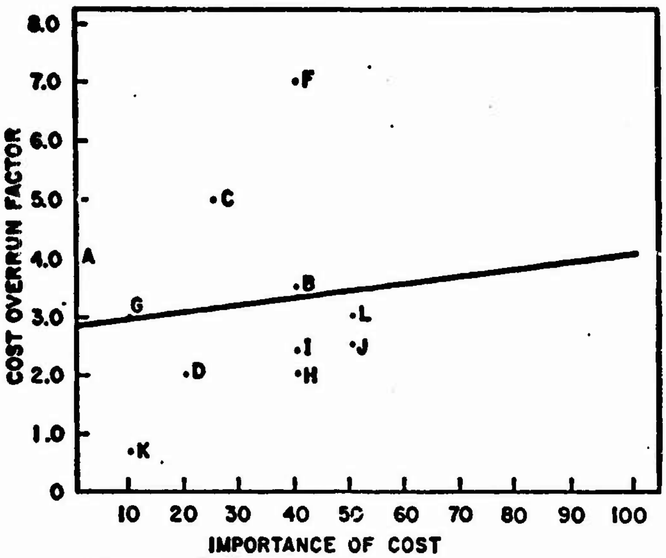

Figure F-6

Correlation of Cost Overrun Factors with the Importance of Minimizing Cost

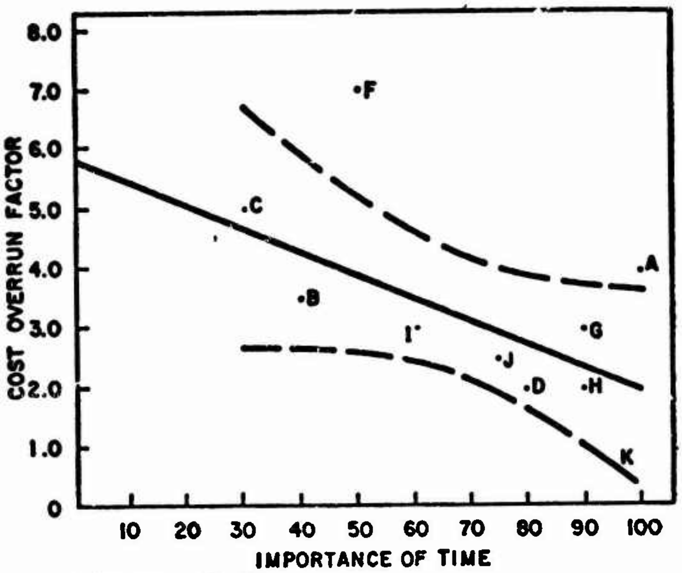

Figure F-7

Correlation of Cost Overrun Factors with the Importance of Minimizing Time

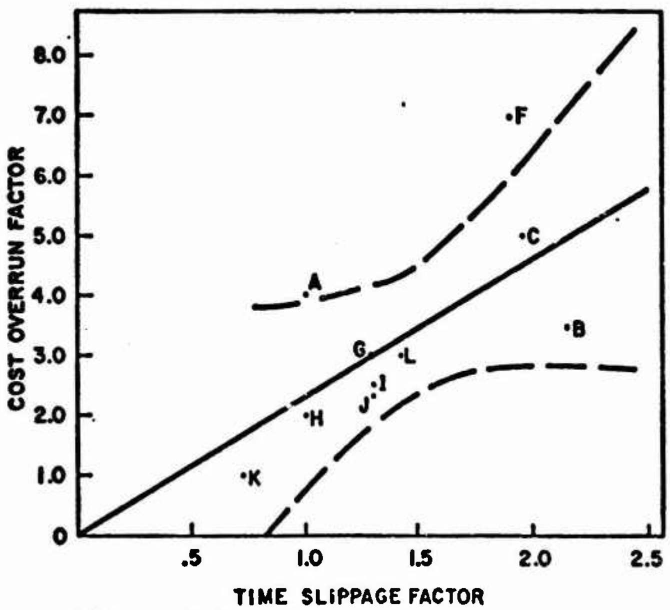

Figure F-8

Correlation of Cost Overrun Factors with Time Slippage Factors

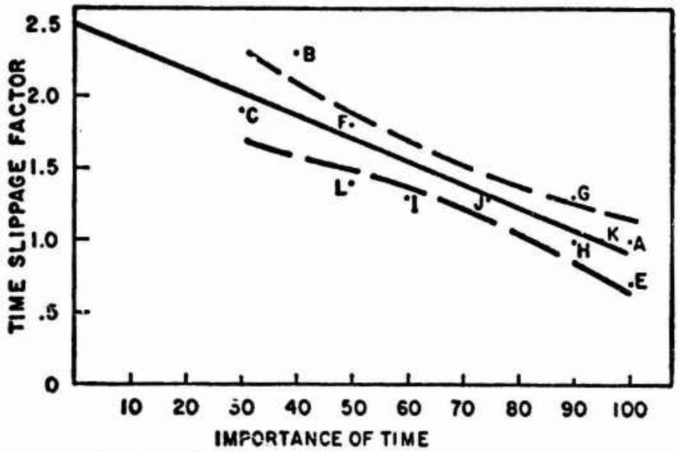

Figure F-9

Correlation of Time Slippage Factors with the Importance of Minimizing Time

Source:
Scherer and Peck, pp.425-51.
(Based upon a study of twelve major weapons systems procurements.)

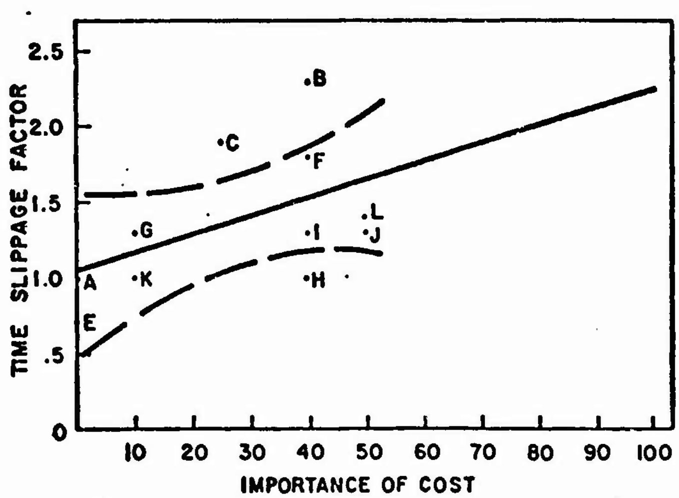

Figure F-10

Correlation of Time Slippage Factors with the Importance of Minimizing Cost

On the other side of the coin, we see that projects which relegated the time constraint to third place behind quality and cost ended most successfully.

The procurement agency can optimize the number of alternatives pursued by considering a number of factors.

1. The number of alternative approaches may be limited by the technology or specifics of the problem.

2. The need for multiple approaches varies with the amount of uncertainty present in the R&D stage.

3. The number of alternatives varies with the cost of pursuing a multiplicity, and the amount of "overlap" that is present in the various approaches; overlapping regions do not need multiple approaches, whereas unique features may.

4. Different approaches are associated with different rates of learning, such that pursuing "staged" or sequential projects in parallel might reveal more total information than if conducted simultaneously, or not at all.

5. The value of different approaches, at the margin, may differ considerably.

These five factors are the elements of the decision. If the agency feels encumbered by the informational weight of having to optimize the decision, it may take the easy way out -- by either not pursuing multiple approaches at all, or by launching too many projects.*

The movement towards multiple projects must be tempered by two observations. First, the coordination effort and expense incurred by the agency may overwhelm its resources. In other words, the technical or organizational constraints in managing big projects may swamp the information benefits of running parallel R&D. This case of information overload is not uncommon in large organizations. Second, the R&D share of the total project cost has risen from less than 5% in pre-WW2 acquisitions to more than 20% by 1960.** The reason is that it has become more important to employ state of the art technology in weapons systems, as part of an overall deterrent

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*Ibid., pp. 488-490

**Ibid., pp. 25-27

strategy. Large investments in relatively unknown technologies serve as signals to the enemy that its own technology may be obsolete. The signal is self-perpetuating, hence a form of R&D escalation results. Some of the unproductive aspects of engaging in esoteric R&D may be explained by the signalling function, since it would be risky for the rival to ignore the potential payoff (no matter how small the probability) if it would obsolete all current capabilities.

The early research commits the government to relatively small costs. Each successive commitment costs more, but is accompanied by decreasing uncertainty. In this non-market of procurement, the buyer would be well advised to streamline the early "preference formation" stage, and facilitate the free flow of information between all participants. Otherwise, the potential benefit of R&D is eroded. If the whole point of uncertainty reduction is to generate useful information, then any block (in the form of administrative delay or "sticky" channels of communication) dilutes the impact of the information.

The agency faces an interesting set of tradeoffs in its information gathering function. It wants to support multiple R&D projects to maximize the number of options available and to serve as cross-checks; but increasing the number of voices increases both the coordination costs and the actual support costs. It wants to delay the final procurement decision as long as possible in order to accumulate information, but it must balance that with the overall time horizon of the project. Generally, "the more entrants the buying agency retains, the greater is the likelihood that it will be offered a clearly superior weapon."* But supporting multiple hardware developments on a competitive basis (such as building two complete nuclear submarine prototypes and then choosing the best one) is impossible. Therefore, the agency should shift its resources and attention to the early stages, where actual costs are low and uncertainty reduction is high.

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*Ibid., p. 350

Multi-Year Contracting

Proper use of multi-year contracting, as reported by the Commission "appears to have yielded impressive results. In a survey conducted by the Commission, DoD reported annual savings of over $52 million, attributable to the use of multi-year contracting for fiscal years 1968-1973. These savings resulted from spreading the nonrecurring costs over several years, the purchase of items and services for more than one year, and the increased efficiency of a stable labor force."* Such obviously desirable and efficient contracting practices require even greater cooperation between all actors in the system. If Congress feels that it is not getting the straight story, it would be loathe to grant such blank-check commitments; if the procuring agency is unsure of its budgetary future, it too would shy away from making long term commitments. In an atmosphere of uncertainty and poor coordination, such cost-saving innovations in contracting would be foreclosed.

Subcontractors

Subcontractors present both an advantage and a cost to the procurement process. Prime contractors have the option of using subs as a substitute for developing highly specialized in-house management or production expertise. This added flexibility gives the primes more time to concentrate on the overall project performance, and relieves the procuring agent from having to coordinate a multiplicity of vendors each with a specialized capability. The "make or buy" decision can be made rationally by the firm, using profit as an evaluation measure, since at this stage of the project, uncertainty has been reduced to a minimum. Also, the prime is relieved of having to carry excess capacity, and can hence deliver a project at a lower total cost. The "peaky" processes can be averaged through using a host of specialty shops. Even though a sub's overhead is addded to the cost of the project,

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*Commission, op. cit., Vol. 1, p. 28

the relief on the prime is justified for the overall project cost. It is for this reason that around half of procurement revenues end up in subcontractor shops.

However, the heavy use of subs carries a penalty with it. The job of coordination leaves the hands of the procuring agency, but so does feedback information and control. Very often, the contract terms that apply to primes are dropped for subs. The procuring agency may end up knowing less about the project than if it dealt completely with primes, and therefore loses the benefits of the learning curve in designing its next project. In order to benefit from the sub's experience, the agency must establish and maintain clear lines of communication; given today's organizational capabilities -- and information technologies -- this desirable feature is often foregone.

COMPETITION

Competition between vendors can occur at many stages of the procurement process. Peck and Scherer identified four major types:

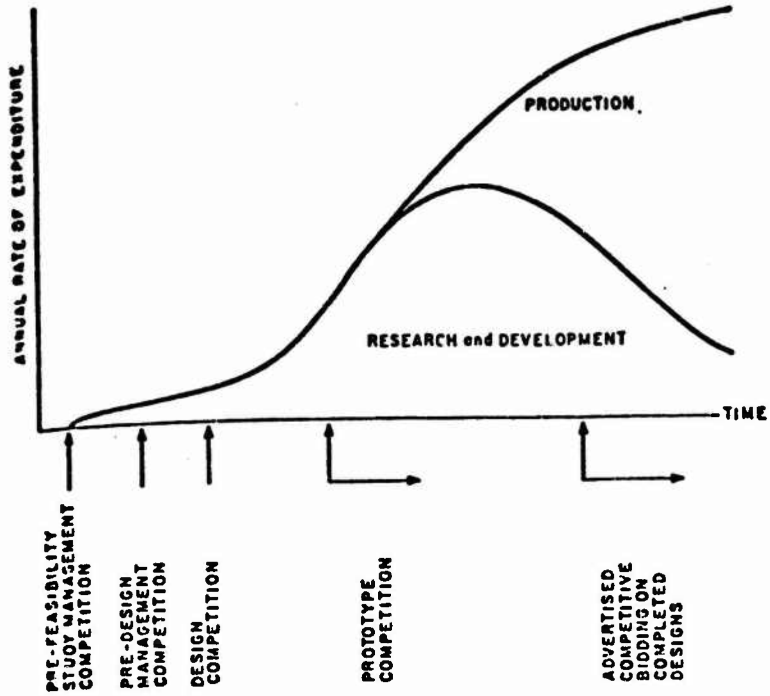
1. Advertised Competitive Bidding. The government issues a precise RFP, and the lowest (or best) bid wins a fixed cost plus contract.

2. Design Competition. The government issues general performance specifications, and bidders respond with detailed design proposals, sometimes accompanied by model.

3. Prototype Competition. Same as above, except that the bidders respond with full-scale working prototype models.

4. Management Competition. In response to a broad statement of government needs, bidders respond with proposals that stress their general technical and managerial capabilities.

The four competitive modes are associated with different stages in the procurement process which are depicted in Fig. F-11. The normal route begins with pre-feasibility studies and management competition. This is followed by pre-design management competition, management competition, and prototype competition. The last stage, immediately before actual system procurement, is the advertised bid competition. Each mode is also associated with different levels of spending. The most commonly used form (advertised competition)



Source: Scherer and Peck, p. 549.

Figure F-11. The timing of various types of competitions within the weapon system cycle incurs the highest level of government commitment. From the agency's point of view, it would prefer to engage in management competition for two reasons: (a) to reduce uncertainty while exploring the widest array of options; and (b) because it involves small amounts of money. However, effective management competition implies a fairly high degree of interaction between bidder and agency. That is, the success or failure of this type of competition depends on the ability of the two parties to communicate their needs and capabilities and to form a loose, flexible, and highly coordinated style of work. In a climate dominated by bureaucratic obstacles and internal uncertainties, this style of operation is unlikely to occur. However, competitive behavior is desirable only up to a point. A prime contractor cannot be expected to bid on every job, since that would require large commitments of scarce technical and managerial talent. At present, the RFP process is extremely time consuming both for the agency and the vendors. Obviously, the cost and time of issuing and responding to RFPs constrains the number and quality of interactions. This is unfortunate from the agency's point of view, because much of the inexpensive uncertainty-reduction takes place precisely at this stage of the game, and to foreclose competitive participation by failing to provide easy communications channels adds a large hidden cost.

Firms are sorted in a quasi-market manner by their capabilities with respect to particular projects. At present, the selection is done by the buyer, not the seller -- a reversal of the neo-classical market sorting mechanism. The profit incentives in large-systems projects favor production-oriented projects over strictly R&D efforts, since plants are normally geared towards the production line activity. In addition, the cost of participation in R&D projects appears to be composed of fixed and variable costs: management overhead is "fixed" in the sense that, over a given threshold, the cost of taking large projects does not increase as fast as the revenue. For this reason, firms prefer to choose projects that match their capacity, and tend to pick large projects (relative to peak capacity) over small projects. Their performance is improved since the project represents a larger portion of their total activity and is relegated greater importance and visibility in the corporate structure; if a company fails in a project which represents 50% of their billings, it is a much more catastrophic outcome than if the project represents only 1%. This observation must be balanced by the awareness that diversified firms, doing business with firms other than the government, are much more stable -- personnel turnover is less, the firm enjoys greater market security which is reflected in its ability to raise capital, and it feels a greater responsibility to its "brand name."

The benefits of competition are maximized, therefore, when the procuring agency can (a) "pre-sort" the solicited firms according to optimal size, (b) encourage sub-contracting the job to match firm capabilities with sub-task needs, and (c) maintain the same coordination and communication standards as with a single contractor.

Competitive Optimism

An undesirable feature of the non-market sorting process is the widespread use of competitive optimism. Scherer and Peck estimated the extent of the optimistic bids in relation to overruns in cost and time. (See Table F-6) They discovered that on the average, cost exceeds the original prediction by 220%, and time exceeds the estimate by 36%.* In ordinary markets, systematic and pervasive over-optimism on the part of sellers would have disastrous effects, especially if pricing contracts were violated. Such abuses would result in endless litigation, frequent bankruptcies, and buyer suspicion. But in government procurement, the penalties for over-optimism are neither frequent nor severe, and in fact the practice is widely encouraged. Much of this undesirable optimism is induced by the structure of the procurement process itself. An agency is beholden to Congress for final budgetary approval. It therefore enjoys greater flexibility if it supports a large number of under-funded programs than a small number of properly funded ones. As programs prove more or less useful, the agency can "compromise" by dropping the less success-

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*Scherer, op. cit., p. 412

Table F-6

COST AND TIME OVERRUN

Development Cost and Time Variance Factors in 12 Weapons Programs

Program •	*Development Cost Factor* †	*Development Time Factor* ‡
A	4.0	1.0
B	3.5	2.3
C	5.0	1.9
D	2.0	n.a.
E	n.a.	.7
F	7.0	1.8
G	3.0	1.3
H	2.0	1.0
I	2.4	1.3
J	2.5	1.3
K	.7	1.0
L	3.0	1.4
Average	3.2	1.36

• Each letter refers to a separate weapons program. We shall use this same code throughout most of this volume; i.e. "A" in subsequent tables will refer to the same program as in this table, unless otherwise indicated.

† Actual cost ÷ original cost estimate.

‡ Actual time ÷ original time estimate.

ful ones in exchange for a higher level of support for more fruitful projects. And low-level projects, as estimated by the vendors, are easier to justify internally -- and are therefore encouraged. However, the agency can enjoy the same flexibility in a more honest and straightforward way by altering the institutional incentives. Scherer and Peck suggest that "when a good deal of time and technical progress intervenes between the submission of initial estimates and the substantial revision of those estimates, contractors can attribute original errors to uncertainty and say that revisions resulted from subsequent learning ... however, it was possible to circumvent this measurement problem when estimates were revised very shortly after a competitive situation and when contractor personnel were willing to disclose the strategy incorporated in their initial bids."* Accomplishing such revisions of estimates requires much closer coordination between agency and vendor. The best of all possible worlds would be achieved if the two parties could collaborate in the formation of the bid response, so that the final decision was a result of numerous small incremental decisions throughout the entire bid process. At present, such close feedback is supplanted by one major bidders conference at which time many of the crucial decisions and much of the thinking is frozen. The standard operating procedure is that a procuring agent will not scrutinize the time and cost estimates too closely for fear of jeopardizing the whole project. This is exactly backwards from normal market purchasing. See Table F-7.

R&D Competition

The marketplace for Federal R&D procurement differs from a purely competitive one in at least three aspects:

1. The size of its purchases usually makes the government a significant, frequently the dominant, and in many fields the sole buyer of R&D.

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*Ibid., p. 414

2. Evaluation of the product is intrinsically impossible in R&D because of the importance of such qualities as innovation, usefulness, and other "non-measurable" attributes.

3. Freedom to enter or leave the marketplace is sharply constrained by security classifications, protection of proprietary information, etc.

R&D competition is particularly hampered by the nature of the commodity being procured, namely information. The Commission on Government Procurement devoted an entire volume (Vol. 4) to the issue of confidentiality, copyright, and patent protection, and came away with very little in definitive policy recommendations.

The problem, from a theoretical point of view, is that attempts to protect information through legally backed appropriation (such as patent) contradict the very nature of information. Information is not a commodity like refrigerators or money; its ownership is difficult to safeguard by the normal application of property law. If you and I both have the same information, it is difficult to prove who had it first and who really owns it; furthermore, the information cannot be taken away from either of us, since once revealed, information all but loses its appropriability. Yet the natural tendency is to try to "commoditize" information by building safe walls around it.

In practical terms, people need incentives to conduct information or knowledge producing activity. The best incentive is that they, and they alone, will benefit financially from the fruits of their labor. Many R&D suppliers feel anxious that their work will somehow be exposed to the world before they can exploit its full financial benefits, and this attitude creates problems for the procuring agency. The Commission's main conclusion in this area was that the government should assume liability for unduly "leaking" confidential information, and pay damages to any vendor who is thereby wronged. The Commission later noted, however, that it would not expect a flood of litigation to result from this policy. Why? Because damage would be extremely difficult to prove, given the nature of information.

The question of R&D procurement remains open and one can only speak in generalities. First, it seems *prima facie* contradictory to convert information into a commodity, and pursuing that path may prove fruitless. Second, the procurement process itself should become more organized and efficient so that errors of omission do not result in violation of a firm's confidentiality. Cases of outright abuse -- such as rifling through filing cabinets and copying blueprints or bid information -- are both rare and easy to prosecute. The real culprits are the sloppiness and innocent mistakes that can easily occur in a system of such complexity. If technological safeguards can be implemented in the procurement process, then R&D suppliers will feel much more comfortable, and therefore communicate more openly with the agency.

DELAY IN THE PROCUREMENT PROCESS

We know that time, cost and quality are functionally related. This is especially true for technological procurements that push the state of the art. Therefore, undue delays in the procurement process, at a given cost level, result in a lower quality product. Alternately, time delays at a given quality level result in higher costs. It is well known that lead time in U.S. procurement projects is inordinately long, ranging from 8-15 years for weaponry (average 10 years), compared to 5 years in the USSR.* Technological uncertainty is one cause for the slippage, especially if crash projects are involved, but are not the sole cause. Scherer and Peck studied 12 programs in detail and concluded that cost overruns can be explained in part by (a) the importance of time in the overall project and, to a lesser degree, (b) by the importance of cost. "The more important minimizing development time was, the smaller was the development cost overrun.** However, the higher the time slippage, the higher the costs, a condition particularly aggravated by high inflation rates. From the agency's viewpoint

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*Ibid., p. 425

**Ibid., pp. 438-444

it minimizes cost overruns by (a) placing high priority to time limits, and simultaneously (b) keeping close track of the project to minimize slippage. This requires heavier participation by the procuring agency, and a more constant stream of information between procurer and vendor. The information, moreover, should be clearly organized to reveal potential time slippages well in advance of their actual occurrence. A signal that a vendor cannot meet his obligation can trigger an immediate search for relief. This can take the form of immediate sub-contracting, or requirement that additional vendor resources be applied to the problem area. At present, it is to the vendor's advantage to conceal (or at least not overtly reveal) potential time overruns, since the formality of merely charging the subsequent cost overrun when the agency approves a crash program remedy is fairly painless. However, if the vendor knew that the relevant scheduling information was subject to constant review, it would encourage him to meet deadlines by more aggressive planning and internal control.

Another cause of long lead time is that small decisions are delayed during the process. The time consumed in transmitting fairly routine technical and financial decisions has been severely criticized.* Scherer and Peck offer three explanations for such administrative delay:

1. The involvement of many groups, in decisions on projects as complex and interrelated as weapons systems, is inevitable; neglecting to properly coordinate would result in waste and inefficiency of scandalous proportions. "The problem is not to eliminate coordinating actions and to reduce the number of people involved; it is to minimize unnecessary involvements and to hasten the resolution of questions among those who are rightly concerned with them."

2. The government bureaucracy is distinctly risk-averse, so any decision needs consensus of a large number of people, each trying to minimize his exposure in case the decision proves embarrassing. This causes small, but significant procedural delays when summed over a large project. The more serious case is when a decision is significantly con-

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*Ibid., p. 452

troversial that agreement cannot be reached. Here the problem is not so much one of eliminating bureaucracy as it is of establishing suitable means of timely conflict resolution.

3. Decisions that affect the "critical path" of a project cause more severe delays than decisions that are marginal. It is of some note that in low priority projects, decision delays were much smaller. The recommendation that emerges is that the procuring agency should find an organizational remedy to allow more decentralized decision making. The relevant information stream should be flagged if it involves critical path decisions; if so, a crack force should be gathered to dispense with the problem. Otherwise, the decision should be handled expeditiously by the appropriate official.

Technical decisions are normally best handled by the vendor, not the procurement agent, since the hands-on expertise is sometimes not present within the government. Many decisions which are sent back for approval, therefore, are an artifact of the procurement process itself. The process of developing a successful bid is sufficiently complex, and the revision procedure sufficiently cumbersome, that a built-in bias exists against changing contracts once established. This is indeed a costly practice, since some of the best learning, and uncertainty reduction, occurs immediately after the project is commenced. The contractor may discover that he is working on the wrong problem, or that major revisions are necessary. But since the burden is on the vendor to prove that he is behaving in good faith, in an environment which is less than conducive to open discourse, he will find it easier and safer to "sit" on innovative ideas rather than incur the costs in pursuing contract changes. The agency is defeating its purpose by thus prejudicing contract changes; but the incentive is understandable. It is difficult enough to keep track of a normal job, let alone a dynamically changing project. The informational difficulties incurred by both parties militates against optimal behavior: change is discouraged.

Efficiency and Productivity

There is some evidence* that purchasing and subcontracting administration is the weakest aspect of defense contractor operations. At a time when all government procurement (and spending in general) is coming under severe budgetary pressure, such inefficiency is a natural target. The magnitude of the resource constraint is illustrated in Table F-7. If we are looking for ways to improve productivity, then the procurement function is a natural hunting ground. An important distinction should be made at the outset between the traditional use of productivity and how we view the concept. The traditional measure is the ratio of output to labor input. It seems, however, that a more meaningful measure would take into account the opportunity cost of the whole procedure. The broader question is: given an endowment of labor, capital, natural resources, and technical (and organizational) information, what is the best use that can be made of these inputs. These variables are highly interactive, so the optimization is not an obvious one. For example, a variant of the Averch-Johnson effect exists in the procurement game. One of the worst sins that can be committed by a production unit is failure to meet a deadline. Since the total capital input is usually fixed, overruns in this area are not easily chargeable to the government. On the other hand, additional labor inputs *are* chargeable as direct cost. The incentive is clearly present to over-staff projects. The interaction between technology and capital is obvious: cost-saving technology may cost more to develop, but saves not only in the final product, but in the generalizable knowledge that may be gained during the project. Productivity, therefore, is not an easy metric to apply in the procurement field. Maybe the only generalization which can be applied is that responsive, streamlined and efficient management is the key to successful projects. Management in all phases of the procurement process can mean the difference between success and failure of the primary objectives -- securing the best

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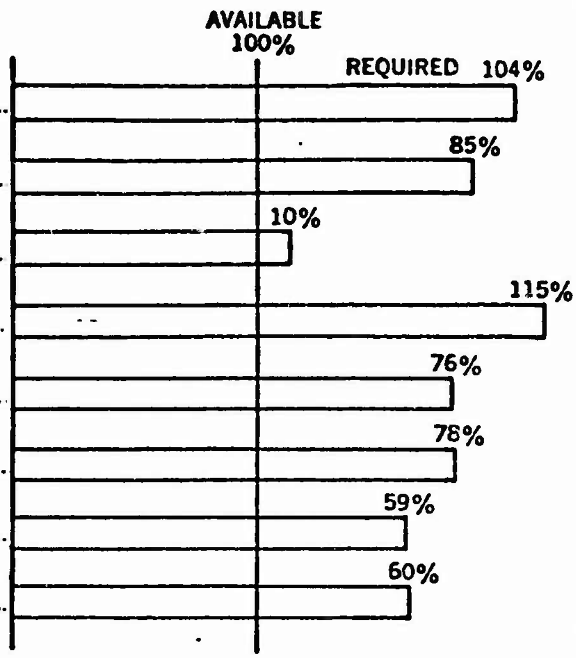
*Ibid., p. 512

Table F-7

THE FUNDING PROBLEM IN WEAPONS SYSTEMS PROCUREMENT



(MILLIONS OF DOLLARS)

	TOTAL FUNDS NEEDED	AVAILABLE	ADDITIONAL REQUIRED
ASW AIRCRAFT	613	300	313
ARMORED VEHICLES	461	250	211
NAVY SHIPS	2390	2200	190
ARMY AVIATION	700	325	375
AIRLIFT & TRAINING A/C	352	200	152
TACTICAL AIRCRAFT	4252	2400	1852
OFFENSIVE STRATEGIC	3230	1900	1330
DEFENSIVE STRATEGIC	1567	950	617
TOTAL	13565	8525	5040

Source: Armed Forces Management Association—National Security Industrial Association Symposium Proceedings, Cost—A *Principal System Design Parameter*, Aug. 16–17, 1972, p. 29.

service from the resources. The RFP formulation, the bid negotiation, the work in process, and the evaluation stages must be streamlined.

Risk-Taking Incentives

A not so obvious area where administrative blockages may cause unproductive behavior is in inducing the vendor to assume risk. An unresponsive procurement agency can cause good ideas to go unheard, good decisions to go unmade. The contractor is loathe to risk his reputation and capital on an idea that, if suggested, can only cause him grief. Scherer observes that "by bridging such intervals of government resistance to change and/or indecision, contractor risk-bearing hastens technological advance, saves lead time, and often eliminates the necessity for very costly crash programs."*

Contractors often decide to assume risk in areas of basic research, component development, feasibility studies, program continuation, and plant improvement. These decisions should be encouraged by the procurement agency, since they serve to spread risk to more parties, and hence increase the real commitment to a given project. The agency has means at its disposal to encourage such decisions, and unfortunately many are not used.

If an agency is not equipped to handle unsolicited proposals, and insists that all work must conform to rigid competitive bidding standards and flow through normal channels, then innovative suggestions will tend to be shelved. If, on the other hand, an innovative idea can be spotted quickly, and the administrative barriers kept to a minimum, such ideas will tend to flow more easily and be rewarded more consistently.

Another area in which streamlined operations can assist productivity is in coordinating activities in a creative manner. Assume that a vendor would like to bear some risk, say by funding

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*Ibid., p. 529

an independent feasibility study. The procurement agency can encourage such behavior in several ways. First, if it can immediately process the proposal, and evaluate it in terms of broad agency requirements, it can give feedback to the innovator whether or not the proposal seems to be on track. Very often, the left hand of a big agency does not know what the right hand is doing, or has done, and certainly does not know what it is planning to do. This is clearly an informational failure: it could be remedied if organizational or technological solutions could be devised to yield a comprehensive view over the entire organization's operation. With today's practices, an innovator would be loathe to take on risk without the knowledge (within reason) that (a) no one else is pursuing the same project in another corner of the organization, and (b) that the risky activity "fits" somehow within the broader aspect of the agency's mission, especially if the future payoff seems high. By supplying such an informational service both internally and externally, the procurement agency could in actuality set up a speculative market for its own needed services, a highly desirable outcome.

Another method of encouraging risk-taking is by helping the innovator in his informational needs. For example, in NASA's Project Rover (nuclear rockets), the agency let study contracts on the proviso that bidders agreed to put up risk capital. The winner, however, was expected to have the "inside track" on future bids in this area. To insure such a presumption, the agency released long-sought AEC data to the recipients of the contract.* In other words, the agency created an information market where one did not previously exist. By organizing its own information resource (i.e. data), it was able to appropriate the information, and get risk capital in exchange. In a more general context, the agency can play the same game by organizing its own accumulated information library, consisting of raw and analyzed data, research,

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*Ibid., p. 532

analysis, management reports, and so on in a way which can be made useful to the potential risk-bearer. Thus, if an agency is apprised of an innovative idea, it can make its information useful to the firm on demand. This is clearly an asset to both sides.

Timely Financing

Between 1964 and 1973, of the 129 regular appropriations approved by Congress, only seven were approved prior to the beginning of the fiscal year. On the average, bills were 94 days late. The Commission was alarmed at the gravity of such delays, citing numerous inefficiencies resulting from the failure to coordinate. One company representative explained the impact of the delays as follows: "We have been forced to work with extremely short lead times for bid and proposal preparation in many cases, and to perform tight, difficult and sometimes impossible delivery schedules. Funding delays cause layoffs followed by associated startup problems and excessive administrative costs. We found it necessary to take excessive risks by spending monies in advance of contract receipt."* The first impact is possibly the most serious. By forcing the firms to respond to the RFPs too quickly, the agency is undermining its procurement effort before it is even launched. For much of the most crucial thinking occurs precisely at the RFP stage, and many viable options may be precluded simply because the administrative sluggishness internal to the agency caused severe time restrictions externally.

Lastly, an agency can increase the likelihood of risk-bearing if it can insure, with some degree of certainty, that risk capital will be figured into the next fiscal year budget. The state of budgeting within the DoD is sometimes chaotic. An agency often finds itself with insufficient funds to continue existing programs, and therefore there is a strong bias against innovating by speculative investment. An agency may sometimes be forced to shift funds internally (outside Congressional authority) to meet an

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*Commission, op. cit., pp. 69-70

unanticipated budget crunch, or seek higher than planned budget for next year, or sometimes even scrap viable projects for no other reason than the funding expired. If this is the case for "normal", or approved projects, then the picture for would-be innovators is dismal indeed. The risk that the money committed will *never* be reimbursed is too high. The best way to turn around this disincentive is for the agency to adopt reliable, streamlined budget management systems such that the necessary information regarding budgeting deficiencies and opportunities are clearly flagged. This is an information-intensive support function, since it requires large amounts of reliable data to feed a management information system. The agency, therefore, has another reason for adopting organizational and technological changes that would facilitate the rapid handling of financial information and coordination.

EVALUATION AND AUDIT

Due to many of the coordination failures cited above, firms and procuring agencies sometimes find themselves in irreconcilable positions. These lead to disputes, audits, and litigation. Since the real culprit is often the system itself, such litigation may be unsuccessful in locating the real perpetrator and the real victim. Cases of gross misunderstanding are much more common than cases of deliberate fraud. In any event, the source of the breakdown returns to plague the disputants in an ironic manner. Since many cases can be settled factually, one would imagine that a simple record search would reveal who said what to whom. Not so. Since the procurement information system lacks system-wide integration, audit trails are difficult to follow. All parties, it seems, would be well served by the existence of such an information system, since then, disputes could be settled on fact rather than allegation.

THE TRUE COST ICEBERG

The visible portion of the procurement activity involves the large government establishment plus the individual firms.

Estimating the true cost of a less than optimal system necessarily goes beyond the visible portion, into regions of secondary effects. By necessity, these estimates can only be stated qualitatively

The tip of the cost iceberg is the actual Federal manpower commitment to the procurement process. Carson E. Agnew* has estimated that manpower commitments in the DoD alone amount to 50,860 man-years costing $732 million. The average high-value procurement consumed 70 days of direct labor, at a cost between $8000 and $10,000. At the other end of the scale one finds a similar industry expenditure on procurement personnel; since the government is more centralized than its vendors, we can assume that industry also spends around $700 million on direct costs of procurement. When indirect costs are computed, for overhead and secondary manpower support, the figure could easily double or triple. A crude estimate, therefore, yields a manpower cost (direct and indirect) in the neighborhood of $2 billion per annum.

The next tier in the true cost iceberg involves the opportunity costs incurred by unnecessary delays. Given a $50 billion annual procurement bill, any idle resources represent capital that could be more productively used elsewhere. If 10% of the capital could be saved by speeding up the procurement process, then at a 10% market rate of interest the system could realize a $500 million annual saving. In addition, the saved capital would presumably earn a return in alternate usage.

Long delays, however, introduce more subtle costs than the simple direct cost cited above. In cases where the technology is changing rapidly, a long delay may mean the difference between acquiring the state-of-the-art tool and acquiring something that is almost obsolete. The true costs, then, are more accurately represented by a dynamic stream of benefits that degrade over time. If the technology is volatile, the time from introduction to obsolescence may be very short indeed. For example, computer

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*Carson E. Agnew, "The Magnitude of the Procurement Activity: A Preliminary Assessment" in *ARPANET MANAGEMENT STUDY: New Application Areas*, Cabledata Associates, Palo Alto, May 1974, Appendix D. (This is the first Quarterly Technical Report of the present project.)

technology in large scale integration (LSI) has caused many components which are only a year old to be non-competitive. The Federal government is a heavy user of computer technology. Much of the equipment is custom-designed for particular needs. In such cases, the opportunity cost of delaying the ADP acquisition can be very large indeed.

Cost and time overruns represent another large penalty which can hopefully be trimmed. As was argued above, the very process of procurement builds in the wrong set of incentives and actually encourages cost and time overruns. Recent estimates have concluded that almost 1/3 of the procurement budget is consumed by such overruns.

A hidden cost, but one which may be larger than all the above combined, is the failure of the system to encourage feedback and learning. The procurement process is so cumbersome and unwieldy that change and innovation after the contract is signed are discouraged. Changing a contract means dealing with the bureaucratic constraints and pressures: review chains, forms, sequential approvals. If problems occur during the contract, which is inevitable in highly complex projects utilizing unproven technology, then the burden of proof is on the firm to justify the proposed change. Guilt and recrimination are, it seems, joint products with any major procurement. The "learning curve" is not properly utilized. Valuable experience accrued during the execution of the contract may be buried and forgotten. From a biological point of view, one might call procurement a "slow-learning" system, since it systematically discourages the generation of feedback information. Continuing the analogy, procurement may be said to lack a reflexive steering mechanism; it has poorly developed sensing equipment, and responds slowly to changes in the environment. The true cost of this failure is difficult to estimate, but it can be assumed to be large.

SUMMARY AND RECOMMENDATIONS

The procurement process has been described as information intensive.

First, we discussed the role of *uncertainty* in introducing undesirable distortions to both suppliers' and consumers' behavior. The relationship between *information* and uncertainty was emphasized in several examples, such as coordination, multiple approaches, multi-year contracting, and competition.

Second, procurement was described as an activity with both high *informational inputs* (R & D) and high *information outputs* (R & D plus product data). In the peculiar "non-market" of procurement, these activities were described to cause resource allocation problems.

Third, procurement was described in items of process *delay*, and the impact of *timeliness* on efficiency and productivity. For example, risk-taking incentives were reduced due to the cumbersome nature of procurement administration. Informational remedies were discussed, such as streamlining communication flows.

These informational problems are intimately related to the organizational and technological structures employed in the procurement process.

What remedies, then, are available to rationalize the procurement process? How can we restructure the environment so that the desirable behavior is induced, and the unwanted behavior is similarly inhibited?

Any organizational or technological proposal must address eight key areas at the heart of the procurement system:

1. Reduce delay throughout the procurement cycle.
2. Reduce uncertainty for all actors in the system.
3. Increase coordination and planning within the system.
4. Streamline the communication and information flows.
5. Encourage timely communication between actors.
6. Increase the usefulness of information by creative organization and rapid access.
7. Provide current and retrospective evaluation means.
8. Encourage feedback information and flexibility in such areas as contracts and bidding.

The Procurement Automation System as described in these appendices is one attempt to meet the eight objectives listed above. PAS represents an integrative concept borne not out of technocratic thinking, but out of an effort to meet an important "market failure" with an organizational and technological innovation.

APPENDIX G

THE COSTS OF ELECTRONIC MESSAGES

by

Carson E. Agnew
and
Paul Baran
and
Ronald C. Crane

ABSTRACT

Ten different ways of sending a one-way message are described and cost compared in this appendix. Mail, mailgram, TWX, Telex, telegram, SNDMSG, facsimile, voice telephone recorders and intelligent terminals which exchange messages late at night, can all serve many of the same needs.

Almost all approaches cost over $6.00 for a 125 word message. TWX/Telex used without paper tape preparation was about twice this cost, and the conventional telegram was over three times as expensive as the other alternatives. Subject to these exceptions, we believe that the choice of the medium used should depend solely on the convenience to the sender and receiver of the message and the response time desired. In cases where an overnight delay is tolerable, the use of an intelligent terminal, utilizing the $0.35 per minute coast-to-coast telephone rate, forms a low cost system. The incremental cost for daytime response using such a system is only $1.45 - 0.35 = $1.10 per message -- still forming an economical approach to high speed message transfer.

The entire cost comparison is shown in Table G-10.

INTRODUCTION

Electronic message transmission systems are not new. A number of different message transmission systems have been built and are now working in specialized applications, including airline reservation systems, large time sharing systems and within some management information systems. The SNDMSG feature of TENEX has proved to be one of the most useful features of the ARPANET for some users.

We are interested in the economics and characteristics of some of the alternatives open, with special emphasis on sending messages on a user-to-user basis at electronic speeds. One particular area of our interest is in automation of the procurement function which is geographically distributed and could benefit to a degree by better, faster electrical communications.

CONTENTS

This appendix examines ten alternative methods of delivering messages between individuals. These are:

1. First class U.S. Mail
2. Registered U.S. Mail
3. Western Union Telegram (day rate)
4. Western Union Mailgram and Night Letter
5. ARPANET SNDMSG
6. Western Union TWX
7. Western Union Telex
8. Intelligent Terminals + DDD
9. Auto-answer facsimile
10. Audio telephone answering device

The alternatives listed are all in common usage with the exception of the buffered intelligent terminal as used in this proposed application. This alternative is included because it does not require central computer or a computer netted switching arrangement, relying entirely upon the commercial or government telephone network used after normal busy hours.

These ten comparative examples are not intended to be complete, only to circumscribe some of the larger spectrum of possibilities for message transfer. We are interested in both the characteristics and the economics of these alternatives to provide background information to the specification of an "ideal" message transfer system with the best of the features of each system and at the lowest cost.

DEFINITIONS

To aid the discussion it is helpful to divide message communications into two classes: "duplex" and "simplex" communications. Simplex communications is defined as that form of communication that permits one-way transmission of information to a storage medium until such time as the receiver is scheduled to receive the message. Duplex communications is that class of communications that is interactive, or allows real-time ability to interrupt and interrogate the transmitter by the receiver. Of course, all simplex systems are duplex in operation by the above definitions if operation is viewed over a long time duration. Thus, a short time period is implicit in the definition.

SIMPLEX COMMUNICATIONS: PHYSICAL STEPS

This appendix deals principally with simplex communications: one-way transmission of information to a storage device to hold the information until wanted. We are interested in the parameters of time, cost and function, which are to some degree interchangeable. In our analysis we divide the communications process into six serial steps for discussion. These are:

1. Preparation of input text.
2. Editing for transmission.
3. Addressing and header preparation.
4. Transmission.
5. Receiver action to obtain message.
6. Reader processing of message.

Let us consider what we mean by each of these steps.

1. Preparation of Input Text

The first step in sending a message is formulating the message to be sent. This takes the sender's time, whether the message is dictated to a secretary, scratched on a piece of paper or composed while sitting at a terminal. When high salary personnel are considered, the cost for additional message formulating time can swamp out some other costs for alternative forms of communications. The ten cent stamp on the envelope of a first class letter does not represent its full true cost.

2. Editing for Transmission

This category describes the time and costs associated with the intermediate preparation of the text to be sent. This would include the preparation necessary to modify the raw message to put it into a form suitable for transmission. This includes such secretarial tasks as transferring stenographic notes into typewritten text.

3. Addressing and Header Preparation

Messages are sent to addresses. And, addresses must be "looked up" in a table, telephone directory, Rolodex or some other file that translates peoples' or organizations' names into transmission addresses. This function takes a little time, depending upon the system used.

4. Transmission

Transmission of the message consists of teleportation of text to the receiver's "mailbox." Communications systems are often compared by the cost and transmission times of the transmission component alone. As will be seen, this can produce misleading overall time and cost results.

5. Receiver Action to Obtain Message

In some of the alternative systems, there is a time delay and price associated with the action of checking one's mailbox for messages. The time and system usage is properly considered a cost component.

6. Reader Processing of Message

Lastly, we consider the operation of the receiver reading the message for the first time. Additional delays can result in some cases where messages are delivered only on special demand.

ASSUMPTIONS IN THE ANALYSIS

We make some general assumptions of a "standard" length message to facilitate comparison of alternative systems. Of course, a longer message would produce greater economies in some systems rather than in others. However, for our purposes we have chosen the following values for the parameters:

1. Only simplex communication mode is considered.

2. The time spent in composing the message by the sender and reading it by the receiver is a constant in all cases: 10 minutes to prepare the message and another five minutes for the receiver to read (or listen) to the message.

3. The message length is 125 words, at six characters including space per word.

4. All systems can be described by the simple model shown in Figure G-1. While six physical actions are shown in this figure, these correspond to three separate logical actions. Each of these local actions is considered as a separate cost element in the following cost analysis, albeit the first and third cost components are frequently neglected in analysis.

5. A cross country telephone billing rate during normal business hours of $1.45 for three minutes (+$.46 each minute over three) is used and the present 8% Federal Excise tax is omitted from calculations.

COST COMPARISON

Cost of Labor and Terminals

Table G-1 lists some of the assumptions used in the cost of labor and for the terminals used in the transmission of messages. (The cost of the communications is listed separately in each service comparison.)

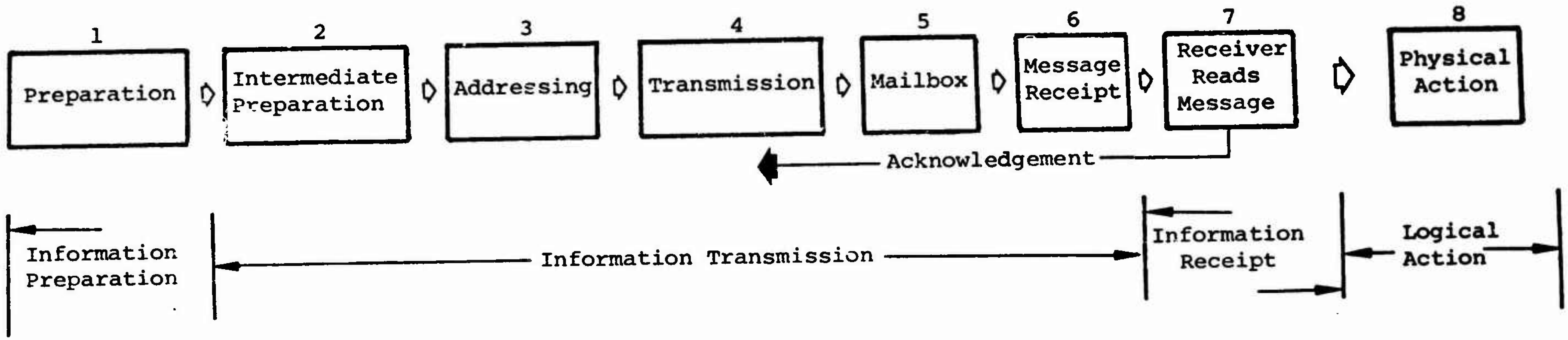

Figure G-1. Simplex information transmission process as described in the paper

Table G-1

COST OF SENDER'S AND RECEIVER'S TIME

Line	Item	Cost	
1.	Salary, mid-level white collar worker	$13,500/yr	
2.	Fringe benefits (at 25% of payroll)	3,375	
3.	Office overhead (at 60% of payroll)	8,100	
4.	Yearly cost		$24,975.00
5.	Hourly cost (2080 hour year)		12.00
6.	Minute cost, labor		.20
7.	Additional costs if three users share a $100 per month terminal and each uses it about 0.5 hours per working day		3.20
8.	Minute cost, terminal usage		.05

Table G-1 assumes that we are talking about middle-grade white collar workers with a base salary of about $13,500, labor fringe of 25% and an office overhead of 60% of base labor cost. This produces an average hourly cost of $12.00, or $.20 per minute, which we use in the following cost comparisons.

In some of the services a terminal is used by the sender (and receiver). In these cases a $100 per month terminal is assumed to be shared by three workers, and that each uses his terminal about 0.5 hours per working day. This produces a terminal-only cost of about $.05 per minute.

Although not shown in Table G-1, whenever secretarial labor is also used, this is computed at a rate of $6.00 per hour fully allocated or $.10 per minute.

Postal Communication

The oldest technology for simplex hardcopy communications is the postal service. Its advantage is primarily in its ability to provide service to everyone at very low communications cost. But, as seen in Table G-2, it is not really cheap when the labor costs are considered, even at the $13,500 salary level and $6,750 for secretarial level labor. Depending upon the combination of options chosen (whether to dictate to a machine or to a secretary; whether to use registered or first class mail, etc.) the costs appear to range from $6.10 to $7.81 per letter.

First class cross country mail has a delivery time from one to three days (but with an uncontrollably wide variance on occasion.) The additional cost of $.60 for registry provides confirmation of receipt, but at the price of an extra delay on the order of an additional day. The range of options yields:

$$\boxed{\text{COST} = \$6.10 \text{ to } \$7.80}$$

Telegram

Table G-3 presents a cost analysis for three different Western Union telegram based services. These are, the full day rate telegram, shown as Option A; the night letter, Option B, and lastly, Mailgrams as

Table G-2

COST COMPONENTS FOR MAIL COMMUNICATIONS

Item	Function	Time	Cost,$
1.	<u>Preparation Costs</u>		
	Option A. Preparing draft	10 min	$2.00
	Option B. Extra cost for dictation to recorder		+1¢
	Option C. Extra cost for dictation to secretary	10 min	+ 1.00
2.	<u>Intermediate Preparation</u>		
	Secretary typing	25 min	2.50
3.	<u>Addressing</u>	2 min	.40
4.	<u>Transmission</u>		
	Option D. First class mail	1-3 days	.10
	Option E. Registered mail	2-5 days	.70
	<u>Receiver Action</u>		
5-6	Fetch mail (by secretary)	1 min	.10
7.	Read mail	5 min	1.00
	<u>Total Cost</u>		
	Options A and D	1-3 days	6.10
	Options B and D	1-3 days	6.11
	Options C and D	1-3 days	7.10
	Options A and E	2-5 days	6.70
	Options B and E	2-5 days	6.71
	Options C and E	2-5 days	7.80

Table G-3

COST COMPONENTS FOR TELEGRAMS

Item	Function	Time	Cost,$
1.	Preparation Costs		
	Composing the message and dictating message to operator	10 min	$2.00
2.	Intermediate Preparation	none	--
3.	Addressing		
	To operator, telephone number and address		--
4.	Transmission (Zone 2 W.U. Tariff)		
	Option A. Day telegram ($4.45 + .12 each word over 15)	3 hrs	17.65
	Option B. Night letter ($3.70 + .03 each word over 100)	12 hrs	4.45
	Option C. Mailgram ($2.00 + 1.00 each 100 over 100)	12-36 hrs	3.00
5-6	Receiver Action to Obtain Message		
	For Mailgram only	1 min	.20
7.	Receiver Action Reading/Listening	5 min	1.00
	Total, Option A	3 hrs	20.65
	Total, Option B	12 hrs	7.45
	Total, Option C	12 hrs	6.20

Option C. The non-transmission portions of the total cost are approximately identical for the three different services, from about $3.00 to $3.20. However, when the electrical transmission costs are added in, there is a great difference in total price. The day telegram which is delivered by telephone call costs $20.65 total. (Plus another $3.00 if messenger delivery is requested, and an additional fee if acknowledgement wanted.) The night letter is much less expensive, only $7.45 without hard copy (or $10.45 with hardcopy.) Lastly, Mailgrams which may be sent via Telex, TWX, or by a voice telephone call and delivered by mail is only $6.20. In summary then:

$ 7.45	Night letter w/o hardcopy
$10.45	Night letter w/ hardcopy
$ 6.20	Mailgram
$20.65	Telegram

COST = $6.20 to $20.65

SNDMSG

Table G-4 shows the cost components for messages on the SNDMSG system supported by the TENEX time sharing system on the ARPANET. This table is generally self explanatory. The source of the costs for the computer central processor system (and memory) and the long haul line costs is contained in a previous working paper (CAWP #120A, by Paul Baran, 21 November 1973). The computer cost for a 125 character message was estimated at $.60, and the pro rata long haul lines at the traffic density experienced at that time was about $.16. The additional pro rata cost of terminal rental is described in Table G-1, line 8. This is added in all the following cases to make the cost basis of SNDMSG and other terminal systems comparable to those that do not require use of a terminal.

Time delay can be anywhere from zero delay to a possible one or two day delay depending upon the frequency that the receiver checks his mailbox.

COST = $6.36

Table G-4

COST COMPONENTS FOR SNDMSG

Item	Function	Time	Cost,$
1.	Preparation Costs		
	Sender logs on	1 min	$ .20
	Sender composes message	10 min	2.00
2.	Intermediate Preparation	none	
3.	Addressing		
	Adds network address and sends message	0.5 min	.10
4.	Transmission		
	CPU Time (from CAWP 120A)	--	.60
	Lease line costs (")	--	.16
	Pro rata terminal costs, dial up (see Table G-1, line 8)	17 min	1.70
5.	Mailbox		
	Receiver logs on to obtain message (including duds)	2 min	.40
6.	Message Receipt		
	Network prints message	1 min	.20
7.	Receiver Reads Message		
	Read	5 min	1.00
	Total		6.36

Telex and TWX

Telex, offered by Western Union, has been combined with TWX, formerly offered by AT&T. As a result, users of each service can now talk to subscribers on the other, and a list of ancillary computer-based services are now available to both sets of customers. Table G-5 lists these Telex/TWX computer-based services and describes the operation of Telex as seen from its terminal input.

A key difference between Telex and TWX is in the type of terminals supported. The Telex terminal uses a small keyboard (3 rows of keys) and operates at the awkwardly slow rate of 66 words per minute. TWX operates with a 4 row upper case only keyboard character set at 100 words per minute and 10 characters per minute respectively. Cross country rates are \$.60/minute for Telex and \$.70/minute for TWX which translates into \$.09/word for Telex and \$.07/word for TWX at the maximum possible transmission rates. The 125 word standard message would then cost \$1.14 for Telex and \$.88 for TWX at the maximum rate using tape transmission (or more likely, with rounded off time, \$1.20 and \$1.40). If one didn't want to use tape, but rather type the message ab initio at an average rate of 15 words per minute to include thinking time, the Telex cost would be \$5.81 and the TWX rates \$9.13 alone for the transmission cost component for transmission of a transcontinental message.

COST = \$6.50 to \$11.31

Voice Telephone/Intelligent Terminal + DDD

As Telex and TWX terminals have a small character set, are noisy and very slow, let us consider the economics of using a more convenient, faster "smart" terminal plus the ordinary direct distance dialed (DDD) telephone. Intelligent terminals need not be expensive -- in the future they will be available at the same cost as the \$100 per month terminal cost assumed elsewhere in this discussion. However, in the following calculation we shall assume a \$200 per month price for the intelligent terminal in Table G-7. A suitable intelligent terminal with auto-dialer would be

Table G-5

TELEX/TWX SERVICES

Computer Service

Mailgram

Mailgram Service is electronic mail which virtually assures next business day delivery to any post office address in the 48 contiguous states if input to the computer by 7 P.M. Destination Time. Mailgram Service is a joint service of the Western Union and the U.S. Postal Service.

Teleprinter Computer Service

Teleprinter Computer Service (TCS) procedures are shown in this directory on page XI. With TCS you can now have these added services:

Telex to TWX Service

Messages can be sent to any one of the approximately 47,000 TWX subscribers in the United States and Canada.

Busy Station Service

Provides an alternative to dialing and redialing when your Telex correspondent's station is busy. Telex to Telex messages can be sent to any one of the approximately 65,000 Telex subscribers in the 48 contiguous states, Alaska, Canada, and Mexico.

Computer Telegram Service

With TCS, you can send messages over Western Union's Public Message System for delivery anywhere in the 48 contiguous states, Alaska, Canada and Mexico.

Computer Dialing Service

You can let the computer do the dialing whenever you have more than one message to send. Dial once to send up to 50 different Mailgrams, Telegrams, Telex or TWX messages and International Telegrams.

Multiple Address (MA) Service

The TCS computer permits you to send the same message to up to 50 different addressees. The addresses can be any combination of Mailgrams, Telex, TWX, or Telegrams.

Computer Collect Service

By using TCS, Collect Service is available to Telex and TWX subscribers in the 48 contiguous states.

International Telegrams (Cablegrams)

Messages to overseas correspondents can be sent through the TCS Computer for onward transmission to the destination. You pay only for the cablegram; the connection to the TCS Computer is free.

Direct and Overseas Service

Alaska, Canada, Mexico

Connections can be made to Telex subscribers in Alaska, Canada, and Mexico in the same way as with U.S. subscribers. Alaskan, Canadian and Mexican Telex subscribers are listed in this directory.

International Telex/Direct Connections

You can have two-way connections with Telex subscribers located in overseas countries (including Hawaii and Puerto Rico) by dialing the International carrier of your choice.

Data Processing

Auxiliary equipment, including computer interfaces, which is particularly useful when using your station for Data Processing is available.

How to make a Telex call

1. Depress START button until DIAL lamp lights.
2. When DIAL lamp lights—dial number.
3. When the connection is made, your teleprinter motor starts, the DIAL lamp is extinguished, and the CONN lamp lights
4. Depress the FIGS and D keys. This will trigger your correspondents identifying answerback.
5. Identify your station by depressing the HERE IS key on your teleprinter.
6. Send your message.
7. When transmission is completed, depress the FIGS and D keys to obtain your correspondent's answerback which serves as an acknowledgement of the call.
8. Disconnect by depressing the STOP button until the CONN lamp is extinguished.

How to receive a Telex call

1. Your teleprinter motor will start, indicating a connection has been made.
2. Your answerback code will be printed automatically in response to the caller's operation of his FIGS and D keys.
3. The caller will usually identify himself by operating his HERE IS key.
4. The message will follow.
5. The caller will usually operate his FIGS and D keys, triggering your answerback to confirm that his transmission was received.
6. The caller will depress his STOP button causing your teleprinter motor to stop. (Either party can at any time terminate a call by depressing the STOP button.)

Table G-6

COST COMPONENTS FOR TWX AND/OR TELEX

Item	Function	Time	Cost,$
1.	Preparation Costs		
	Option A. Punch tape	12 min	$2.40
	Option B. Send directly (TWX)	10 min	2.00
2.	Intermediate Preparation		
	Option C. Send tape (TWX)	2 min	.40
	Option D. Send tape (Telex)	3 min	.60
	Option B. Send directly (TWX)	--	Included in Item 1
3.	Addressing		
	Look up address	2 min	.40
4.	Transmission		
	(Telex/TWX Tariffs)		
	Option B. Send directly (TWX)	8.3 min	5.81
	Option C. Send tape (TWX)	2 min	1.40
	Option D. Send tape (Telex)	3 min	1.80
	Terminal cost, pro rated		
	Option B	20 min	1.00
	Option C	12 min	.60
	Option D	13 min	.65
5.	Mailbox (secretary)	1 min	.10
6.	Message Receipt		
	Option B (secretary)	10 min	1.00
	Option C (")	2 min	.20
	Option D	3 min	.30
7.	Receiver Reads Message	5 min	1.00
	Total, Option B		11.31
	Total, Option C		6.50
	Total, Option D		7.25

Table G-7

COST COMPONENTS FOR INTELLIGENT TERMINAL + DDD

Item	Function	Time	Cost, $
1.	Preparation Costs		
	Composes message	10 min	$1.20
2.	Intermediate Preparation	none	--
3.	Addressing		
	Adds addresses	0.5 min	.10
4.	Transmission		
	Option A. 8am to 5pm (3 minutes)	1 min	1.45
	Option B. Buffered to 11pm (1 minute)	12 hrs delay	.35
	Pro rata terminal cost (@ $200/mo = .10/min under uniform costing assumptions)	22 min	2.20
5.	Mailbox		
	Automatic answer	none	--
6.	Message Receipt	1 min	.20
7.	Receiver Reads Message	5 min	1.00
	Total, Option A, immediate delivery		6.15
	Total, Option B, overnight delivery		5.05

capable of performing such services as calling back later when the called line is busy. Thus, there is little need to use a Telex or TWX type line to obtain access to such computer-supported services (other than most everyone elses' terminals are now accessible via TWX or Telex). Ordinary DDD voice telephone rates are significantly less than TWX and Telex rates for an overnight callup, and even comparable on a daytime service basis. For example, the long distance (cross country) rates for station-to-station voice telephone service are:

8am to 5pm, 3 minutes = $1.45
5pm to 11pm, 3 minutes = $.85
11pm to 8am, first minute = $.35 (+$.20 each add'l minute)

Even a low cost acoustic coupled modem terminal can handle 300 bits per second (300 words per minute). Consider a service comparable to Mailgram delivery rates. Here the user would edit his text and store it in his terminal. An auto-dialup circuit with clock would dump the message at night for a total transmission cost of $.35. Even the mid-day three minute rates of $1.45 for DDD compares favorably with $1.10 for TWX and $1.80 for Telex. Or more fairly the rates for the 125 word message are about $1.40 for TWX and $1.80 for Telex. If buffering is permitted to provide a faster service than Mailgram, then the late night called up circuit ($.35) presents a low cost alternative that can be considered for hardcopy. If immediate delivery is desired, then the DDD $1.45 daytime rate for up to 900 words still looks attractive.

When we consider total costs, we find that the cost of daytime instant delivery would be about $6.15 for the message and about $5.05 for overnight delivery. These numbers compare quite favorably to the other options being considered.

$\boxed{\text{COST = \$5.05 to \$6.15}}$

Facsimile

Using an automatic answering facsimile machine as a message recorder is another way of skinning the cat. Table G-8 describes the gross economics. If the rough handwritten text is acceptable

Table G-8

COST COMPONENTS FOR FACSIMILE

Item	Function	Time	Cost,$
1.	Preparation Costs		
	Option A. Sender writes message	10 min	$2.00
	Option B. Secretary types as letter	20 min	2.00 (Sec'y)
2.	Intermediate Preparation		
	Load message inot FAX unit Dial number	3 min	.30 (Sec'y)
3.	Addressing	1 min	
4.	Transmission		
	Option C. Telephone call	6 min	2.83
	Option D. Telephone call	3 min	1.45
	Pro rata terminal cost (used 100x/mo and $100/mo)		1.00
5.	Mailbox	--	
6.	Message Receipt		
	(Automatic answer) Get message out of machine	2 min	.20 (Sec'y)
7.	Receiver Reads Message		
	Read message	5 min	1.00
	Total, Option A, handwritten note + Option D, small piece of paper		5.95
	Total, Option B, secretary retypes onto 8-1/2 x 11 letterhead + Option C, sends full page		9.33

for transmission, approximately $2.00 can be saved in text preparation. Further, if the text is compressed to a half page so that it can be transmitted in three minutes, $1.38 additional can be saved. Thus, we have a range of costs depending upon the acceptable quality of the received product.

COST = $5.95 TO $9.33

Telephone Answering Device

One obvious message transfer system is that of simply using a telephone answering device. They are cheap, reliable and becoming widespread. However, they suffer the disadvantage of not producing a written text version unless the output tape is transcribed, adding a cost over and above that calculated.

COST = $6.50

CONCLUSIONS

The costs and system delay times for the alternative systems considered are shown in Table G-10. This table speaks for itself and suggests that differences in the costs for the alternatives are generally small. This is to a good measure explainable by inclusion of labor costs. And, it suggests that the choice of communications service should be determined primarily on the users' convenience, as the cost of the technology used is generally a secondary cost.

Table G-9

COST COMPONENTS FOR TELEPHONE ANSWERING DEVICES

Item	Function	Time	Cost,$
1.	Preparation Costs		
	Sender thinks what he is going to say	6 min	$1.20
2.	Intermediate Preparation		
	Sender dials phone and dictates message	6 min	1.20
3.	Addressing		
	Looks up telephone number	1 min	.20
4.	Transmission		
	Telephone call	6 min	2.83
	Telephone answering device $20/mo & 50 calls/mo		.40
5.	Mailbox		
	Checks to see if any messages have arrived	1 min	.20
6.	Message Receipt		
7.	Receiver Reads Message		
	Listens to telephone message	5 min	1.00
	Total		7.03

Table G-10

COST COMPARISON OF SOME ALTERNATIVE SIMPLEX COMMUNICATIONS SERVICES

Speed Range	Delay Time	Service	Cost Estimate, $
Immediate	None	Intelligent terminal + DDD auto dialer	6.15
		TWX tape	6.50
		Voice telephone answering device	7.03
		Telex tape	7.25
		Facsimile	5.95-9.33
		Interactive TWX	11.31
On user's demand	0 to days	SNDMS[illegible]	6.36
Slow	3 hours	Telegram, full rate	20.65
Overnight	est-12 hours	Intelligent terminal late night message transfer	5.05
	est-15 hours	Night letter	7.45
	1 to 2 days	Mailgram	6.20
	1 to 3 days	First class/Airmail	6.10-7.10
	2 to 4 days	Registered mail	6.70-7.80

APPENDIX H

COMING ATTRACTIONS

During the normal course of this study, a communion of assumptions emerged and stabilized as a private "working language." In all fairness to our client, which bears the burden of absorbing a polished product, we felt that inclusion of some nascent ideas would at least etch a faint marker for future traverse. Besides, raw ideas are often more valuable and "true" than their erstwhile massaged descendants, in that they reveal intuition and reflex untempered by caution and deliberation.

In that spirit, we wish to draw attention to work in progress by Paul Goldstein (Attorney) on the subject of *secrecy* and *security*. Mr. Goldstein concludes that sharp distinction can be drawn between the two concepts, and that undue emphasis on secrecy may actually betray the higher aims of security.

His work will appear as an appendix to the Final Report (October 1974). Included herein is a sectional precis of the paper.

INTRODUCTION

This section will introduce the paper by locating the legal issues that will attend automation of DoD procurement, especially at the intersections between emerging technologies and entrenched institutions. The modern concern for databanks' inroads on privacy will be cited as marking one exemplary point of intersection. Present institutions of national security (defense and foreign relations) and industrial security, posing critical points of abrasion with the newer, information-based technologies, will also be considered briefly.

It will be shown that these three institutions -- *privacy, national security, industrial security* -- have traditionally been thought to depend upon secrecy for their security; and that secrecy, to whatever extent it has historically operated to secure these three institutions, will, under the conditions created by the new technologies, tend to erode rather than buttress the security of these institutions. Finally, it will be underscored that secrecy is only a means, with security the end, and that to endorse secrecy for its own sake would be both technically deficient and historically inappropriate.

This paper will focus on the second institutional area identified -- national security. Because industrial security issues are analogically and functionally proximate, they will also be considered in some detail. The paper will not, however, consider privacy and, indeed, will draw a sharp distinction between the interests at stake in privacy and those involved in national and industrial security.

The section will then briefly describe the proposed system for procurement automation, particularly its efficiency payoffs, and will conclude with two observations on the system's implications for security: (1) that security losses will attend the availability of data that, though unclassified, were previously dispersed in recondite channels; and (2) that security gains, measured in terms of increases in defense capability, may be expected to accompany increases in procurement efficiency.

SECURITY IN THE LEGAL ORDER

This section will present an overview and analysis of national security policy as reflected in federal statutes and decisions. The analysis will demonstrate that statutory, judicial and administrative requirements of secrecy have historically occupied only a limited place in the nation's security programs and that secrecy has on important occasions been viewed as antithetical to security needs.

The Business of Government

Secrecy may, by erecting obstacles to intragovernmental communication, impede effective and secure governance. The evolution of Executive Orders respecting materials and data classification, from the initial Truman order to the present Nixon modifications, reflect an increasing concern for unplugging administrative and information channels.

The Interests of the Governed

Secrecy in government has been abandoned to meet other, larger interests that also bear on security. This subsection will consider a central example -- citizen interest in access to information respecting the processes of government. Unlike the security interests considered in the previous subsection, which will obtain under any form of government, the interests considered in this subsection are unique to a democratic form of government. While the withdrawal of secrecy to satisfy claims for public access is often characterized as a sacrifice of "security" for "freedom," it in fact involves a sacrifice of secrecy (security of one order) for political integrity (security of another order). This subsection will consider, among other topics, first amendment prohibitions on prior restraint (*The Pentagon Papers case)* the Freedom of Information Act, and the various federal espionage statutes and their legislative history.

SECURITY WITHOUT SECRECY: THREE MODELS

The posture taken in the first section will be essentially static and descriptive. It will illustrate the limited position that secrecy enjoys in the legal design of national security and the ways in which secrecy has been specifically eschewed as a definite hindrance to security goals. A markedly different approach will be taken in this section which, focusing on *security,* will consider three operative models of security without secrecy. The three -- an "information model;" an "industrial model;" and a "bureaucratic model" -- have been chosen for their relevance to the basic informational structure of an automated procurement system and for their reflection of ways in which important actors -- bureaucrats and government contractors -- behave in a specifically informational environment.

The Information Model

Under modern deterrence strategies, a nation's security position depends not on armaments and preparedness -- the perceptible implements of security -- but rather on the information that its enemies possess about these implements. It is not the actual number of troops and weapons that matter, but what the enemy believes the real capability of the forces will be if tested. If we believe that theory, the United States could maintain deterrence credibility at present levels by deploying believable snapshots of a reality that does not exist. This proposition suggests that national security is predominantly a function of information mangement. That the United States has not found it expedient to rely exclusively on a strategy of baseless pictures underscores the limitations of a security program consisting predominantly of information management. This subsection will consider these two aspects, positive and negative, of the information model.

The positive aspects of a fully accessible security system will be considered in the context of proposals made by Teller (c. 1968) and Oettinger (1971) as amplified by DSB Task Force on Secrecy (1970; declassified, 1972). The argument is that a fully open defense establishment (one abetted by open access procurement functions) is not necessarily inconsistent with national security.

While an open-access system will suffer certain security defects, there is no reason to believe that the enemy will through the system obtain information otherwise unobtainable. Present techniques of surveillance, gaming and analysis of public domain documents pretty much guarantee that the enemy knows, or can discover, all security information that is presently classified and that might be exposed in an open-access system. An open-access system would, however, lower the enemy's cost of obtaining this information. It will be shown that the benefits to be derived from an open-access system outweigh the costs, measured by loss of competitive advantage.

The Industrial Model

Industrial programs of secrecy, generally concerned with proprietary data, relate to government secrecy programs in two significant ways. First, industrial secrecy is the private sector counterpart to governmental secrecy: the advantage over competitors that trade secrets presumably give to the firm find their parallel in the advantage over enemies that military secrets are presumed to convey. Industrial espionage is the private sector counterpart of the better-known public sector phenomenon, and reverse engineering by competitors finds its counterpart in nations' attempts to reconstruct enemy defense positions from publicly available data. Industrial security, to the extent that it has been maintained without secrecy, provides a powerful analogical base for arguing that national security can, at counterpart points, also be maintained without secrecy.

Second, industrial security and secrecy are functionally tied to national security and secrecy. In the sense of security -- and the nation's position of power -- the two are often indistinguishable. In the sense of secrecy, abandonment of secrecy for one may, arguably, entail abandonment of incentive for the other. If, for example, DoD were to decide to declassify and open to the public all procurement-related data, including data submitted by bidders and contractors, firms may be dissuaded from bidding or, because of inappropriability, from investing in innovation.

The subsection will conclude with two observations: (1) that under present conditions, secrecy enjoys only a limited role in the industrial sector, and (2) that secrecy should be assigned a limited role in the governmental sector.

The Bureaucratic Model

Arguments for secrecy in government assume (1) that some should know the secret and some should not and that it is a relatively easy task to distinguish between these two groups, and (2) that within any group that legitimately has access to a secret, all actors will behave with equivalent fidelity. Neither assumption holds up in fact, a point that goes far to demonstrate the diminished role of secrecy in security affairs. The limitations of both assumptions will be demonstrated (the second by reference to Halperin [1974]) and this subsection will conclude with some suggestion of the implications for bureaucratic behavior under an open-access security system.